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Press performance of frequency modulated screen printing on newsprint

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Press Performance of Frequency Modulated Screen Printing on Newsprint

by

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Abstract

Frequency Modulated (FM) screening has been praised for its apparent resolution advantage over conventional halftone screening. Studies showed FM screening can be processed with the existing technology, and it does bring about a visible improvement in image quality on newsprint. This study focused on the press performance of the FM halftone printing on newsprint.

The fineness of conventional halftone screens can be described by indicating the screen rulings (lines per inch or lpi), and the fineness of FM screens is measured by the size of the micro dots (μm or 10^{-6}m). It is difficult to equate the microdot size in FM screen to the screen ruling in the conventional halftone. This research uses the concept of the total border length per unit area on a given % film dot area as a common parameter to characterize both FM and conventional screens. By comparing the border length difference between a number of FM screens to the 85-lpi conventional screen, the results show that the higher the border length ratio, the higher the dot gain of the screen in question. In addition, the maximum border length ratio for a given screen is where the maximum dot gain difference occurs.

This research also investigated if there is significant color variation between FM and conventional screens when solid ink densities are varied. The

Specifications for Non-Heat Advertising Printing (SNAP) recommends an 85-lpi conventional screen for newsprint. UGRA recommends 40μm FM screen for newspaper printing. Therefore, in this study the 85-lpi conventional screen (AGFA Balanced screen) was used as the reference screen. The 42μm FM screen (UGRA Velvet screen) was used for the color stability test. The test run was conducted on the Rockwell positive-feed keyless Newsliner newspaper press. Five inking levels were tested in the experiment with two inking levels lowered and two inking levels increased over the normal inking condition. The normal inking condition was set to conform to SNAP specifications. The results show that there is no significant color variation between FM and conventional screens over a wide range of solid ink density variation.

Chapter 1

Introduction

For more than a hundred years, halftone images have been reproduced by rendering tonal values via crossline screen into different sized printing dots. When four or more colors are printed, conventional screening methods rely on carefully calculated angles and fixed frequency to reproduce an eye-pleasing illusion of true continuous-tone color images.[1] However, the most common problem related to this process are moiré patterns, which are caused by the interference between screens or between screen and image objects. Nevertheless, the traditional halftones give printers a fairly predictable and consistent quality throughout a press run.

Conventional offset printing has limited tone and color rendering capabilities due to the color gamut of the process inks and screen ruling chosen. For this reason, some other printing methods, Collotype and screenless lithography for example, were developed to meet the requirements of some special high quality products. Collotype and screenless lithography reproduce images by using randomly patterned grain structures instead of halftone dots. Therefore, many overprinted colors are possible without moiré.[2] The two processes produce superb color and detail. Because these processes require high levels of craftsmanship and have limited run-length capabilities, these processes have been limited to art reproduction. Black Box Collotype, Chicago, USA, is believed the only remaining commercial participant of this process.

Frequency modulated (FM) rastering was first introduced by the Technische Hochschule Darmstadt in 1983.[3] Instead of creating the tonal illusion through fixed spacing and variable dot sizes as in conventional halftone screening, FM screening uses micro dots (14-50μm) and variable spacing to render the tonal value. Because of the computer's speed limitation and the accuracy of output devices at that time, little was printed using FM screening. In recent years, computers are widely used in the electronic prepress area, especially the PostScript Raster Image Processor (RIP) technology in highly accurate imagesetters. Digital halftones have become the standard for film output. Increases in computer capacity and laser imagesetter technology have made FM screening processes feasible for most production work.

Digital halftones use a cluster of laser spots to mimic conventional photographic halftone dots, but massive calculations are required. On the other hand, FM screening uses random placement of individual laser spots instead of clusters of spots to create continuous-tone like images. At higher addressability settings, clumps of four or more laser spots are used as the elemental unit instead of individual laser spots.[4] Although the placement of laser spots still needs many calculations, both digital imaging and excellent quality can be achieved at lower imagesetter addressability.

In April 1993 at the Sybold Seminar in Boston, both Agfa and Linotype-Hell announced their version of FM raster products, CristalRaster and Diamond Screen respectively. Since then, FM (or Stochastic) screening has become a new "buzz" word. It has been discussed extensively in trade articles. Today, at least 17 FM screening products are available on the market. In April 1995, a survey conducted by Publish & Production Executive magazine showed: 4% of printers are using FM screening, and 26% plan to do so within 18 months.[5]

From the literature review, FM screening is credited with several advantages over conventional screening methods. These benefits are:[6]

1. No visible dot pattern; no built-in structure characterized by screen ruling, screen angle, or dot structure; no rosette patterns due to dot structure.
2. Freedom from moiré patterns.
3. No trade-off between gray levels and resolution.
4. Smooth tonal rendering; no midtone jump.
5. Lower scan and recording resolutions possible.
6. Less need for unsharp masking.
7. Quicker makeready due to less sensitive ink/water balance.
8. Less problem with shadow plugging.
9. Greater latitude in ink density on press.
10. Greater latitude in registration on press.

FM screening also has some disadvantages:

1. Higher dot gain.
2. Higher cost, because FM raster needs greater computational power and speed required for RIP.
3. Proofing difficulties.
4. Cleaner production environment. Especially at platemaking stage. FM screening films require the highest level of care in handling and accuracy in plate exposure and processing.
5. FM screening films are not dot-etchable.
6. Flat tint areas appear grainier than conventional screening tints.

FM screening has been praised for several advantages over conventional halftone screening. However, FM screening is not a well understood process from the press performance point of view by the graphic arts community. In the past few years, FM screening was considered difficult to work with as an alternative to screened halftones and did not necessarily produce a better result.[7] One of the biggest mysteries with FM printing is its high dot gain. A typical 21μm FM printed on coated paper has a midtone dot gain of about 45 to 50%, which is twice as high as the midtone dot gain as indicated in the Specifications for Web Offset Publications (SWOP).[8]

The high dot gain due to the printing behavior of FM screens has to be compensated for in order to produce quality images. The idea is to apply the transfer curve, which is derived from FM and conventional halftones' plate/press curves, to color-managed images.[9] After applying the transfer curve to color-managed images, the FM screened images can be visually matched to the conventional halftone images. Therefore, this method should be able to modify color-managed, conventional halftone images for FM screen printing.

Statement of the Problem

The fineness of conventional halftone screens can be described by indicating the screen rulings (lines per inch or lpi), and the fineness of FM screens is measured by the size of the micro dots (μm or 10^{-6}m). Because there is no screen ruling for FM halftones, it is difficult to decide what spot size FM screen is equivalent to a conventional halftone. However, it is possible to characterize both FM and conventional screens by the total border length per unit area on a given % film dot area. Since dot gain happens at the edge of a dot, more border length results in more dot gain. By comparing the border length difference between FM screens to a reference conventional screen, we can learn more about the dot gain behaviors of FM screens.

On several test runs printed at RIT, FM screens seemed to have less dot gain variation than conventional halftone screens when solid ink density increased. As yet, there was no systematic test to indicate how color varies relative to both decreased and increased solid ink densities.

The study focused on two elements: (1) the relationship between the border length ratio and the dot gain difference of FM and conventional screens; (2) the color variation of FM screens as a function of changes in solid ink density on both low and high inking conditions.

Significance of the Problem

Because of the nature of newsprint and offset newsprint inks, people think newspaper printing is only capable of coarse quality and low resolution images. But the use of FM screening on newsprint might change this opinion. The literature states that FM screening can be processed with the existing technology, and brings about a visible improvement in image quality on newsprint. While most newspapers use a conventional screening range from 85 to 100-lpi, the screen patterns can be easily observed and images become coarse to the eye. FM screens eliminate the dot patterns and provide smoother tonal rendering with sharper images. The result can provide a major improvement in the image quality on newsprint. The image quality improvement could be so great that looking through the pages and particularly at pictures printed with FM screening would give readers the impression that this is no longer a newspaper but a magazine.[10]

Definition of Terms

The terms which will be used frequently in this study are discussed below:

Laser Spot is the smallest dot which an imagesetter can produce on film.

FM Micro Dot is the basic dot of an FM screen, which is composed by either single laser spot or clusters of laser spots (1x1, 2x2, 4x4 ... etc.)

Clustered dot refers to conventional halftone dots. All the laser spots are gathered in the center of a halftone cell. The distance between conventional halftone dots is constant but the size of the dot changes for different tonal values.

Unclustered dot (dispersed dot) refers to FM micro dots. Within a tonal area, FM micro dots are dispersed randomly. Contrary to conventional halftone dots, all FM micro dots have the same size but different distances between dots.

The total border length is calculated by measuring the circumferential lines along the borders of all dots within a captured picture frame.

Endnote for Chapter 1

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3. Erwin Widmer, Kurt Schläpfer, Veronika Humbel, and Serdar Persive, "The Benefit of Frequency Modulation Screening," TAGA Proceeding, 1992, p.28.

4. Jim Hamilton, "Random Screening Paves the Way for Sharper Images," Printing News Midwest, December 1993, p.3.

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6. Richard M. Adams II and Raymond J. Prince, "How I See It: Stochastic Screening," GATF World, September/October 1993, p.32.

7. Anita Dennis, "Stochastic Aptitude Test," Publish, June 1995, p.55.

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9. Robert Y. Chung and Li-Yi Ma, "Press Performance Comparison between AM and FM Screening," TAGA Proceeding, 1995.

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Chapter 2

Theoretical Basis

The development of electronic screening began in the early 1970's. It incorporates electronic dot generation via the high-end electronic color scanner as an alternative to the traditional photomechanical screening techniques. Today electronic screening is widely considered adequate for the graphic arts industries. This technology seems to provide both appropriate reproducibility and ease of use, while allowing for sufficient flexibility to meet the requirements of image manipulation. In the desktop or PostScript environment, four generations of screening technology have developed.[1]

The first three generations of digital halftoning have tried to mimic the conventional photographic halftones that were first invented in the late part of 19th century. They arrange different sized dots in fixed, angled grids for multicolor printing. Because of requirements of the different screen angles and screen rulings for multi-color printing, digital screening functions became very complicated. Different generations of screening algorithms were developed to overcome the problem of those massive calculations while achieving better quality and higher efficiency.

Frequency Modulated screening abandons the familiar halftone dot and fixed line screen for a random scatter of micro dots to form the image.[2] FM micro dot placement is similar to how a photographic image is recorded on photographic film emulsion. Because the micro dot is very small and randomly arranged, the human eye fails to resolve it. Visually, FM screening is closer to continuous tone effect than conventional screening (see figure 1).

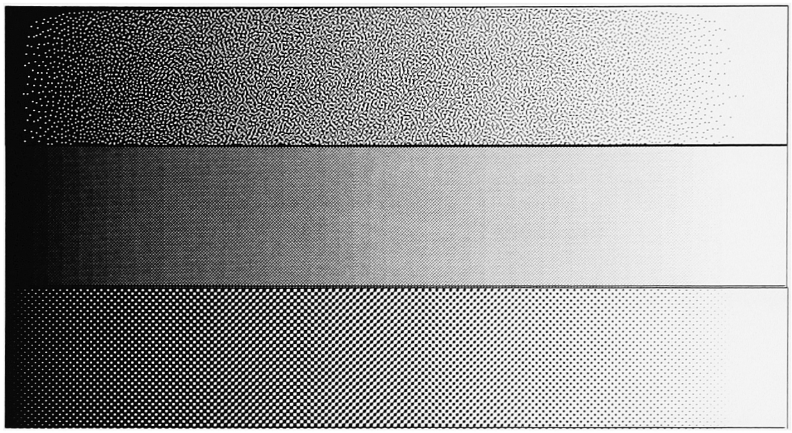


Figure 1. Grayscale tone rendition of conventional and frequency modulated screens. From top to bottom: UGRA Velvet Screen (FM, 169μm spot size), Continuous-tone scale (simulation, by using the maximum resolution of the laser printer), and conventional screen (40-lpi)

Frequency Modulated vs. Amplitude Modulated Screening

In digital halftoning, the terms Amplitude Modulated (AM) screening and Frequency Modulated (FM) screening have been borrowed from the field of signal processing. Similar to the AM and FM radio waves, for AM screening the dot frequency (screen ruling) is constant and dot size varies; for FM screening the dot frequency varies and dot size is constant (see figure 2).

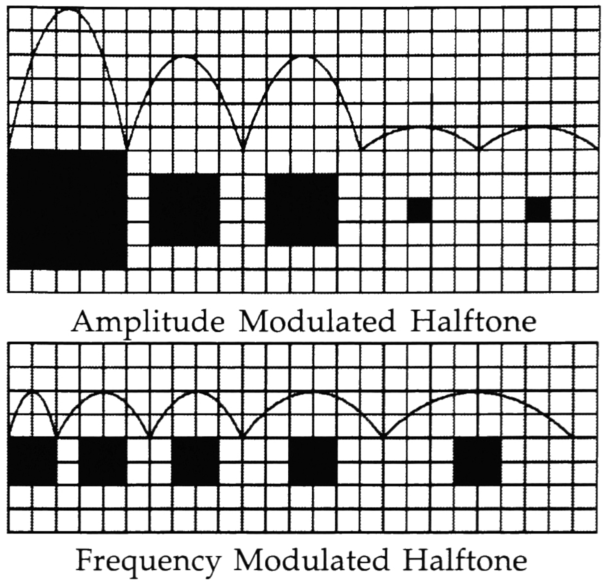
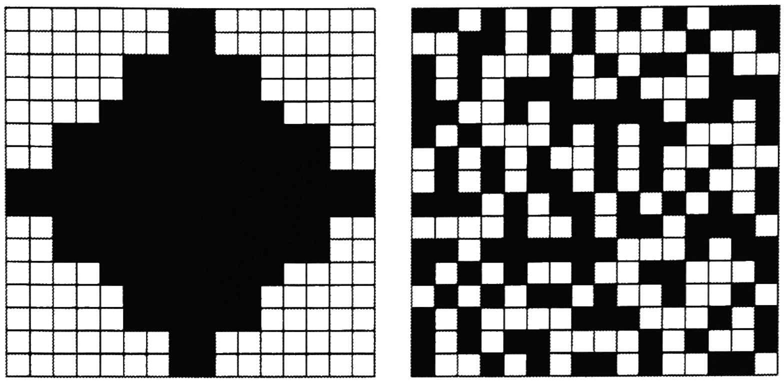


Figure 2. Illustrations of the terms AM & FM screening technique[3]

In the electronic screening process, a halftone dot is usually generated from a cluster of laser spots. A halftone cell is divided into a matrix of single recording dots (laser spots).[4] The number of laser spots within a halftone cell depends on the screen ruling and the resolution of the imagesetter or film recorder. For example, the AGFA SelectSet 5000 imagesetter has a resolution of 2,400-dpi. A screen cell of the 150-lpi conventional halftone screen output from the SelectSet 5000 contains total 16x16=256 (2400-dpi/150lpi=16) laser spots. The size of the laser spots is 10.5µm.

A distinction should be made between AM and FM screening methods in which the recording dots (laser spots) in the screen cell are arranged. The AM screening uses the conventional, compact way (clustered dots), and FM screening where the FM microdots are resolved and dispersed in the screen cell (dispersed dots).[5] (see figure 3)



AM FM

Figure 3. 50% tone. Both AM & FM screen have 128 laser spots per 16x16 halftone cells (128/(16x16)x100% = 50%)

The randomness of FM dots depends on the different algorithms that are used to disperse the laser spots into the screen cells. In several FM screening technologies, however, "random" is a relative term. Randomness is always limited by the addressability grid, therefore AGFA refers to it as "calculated randomness" in describing the dot placement in its CristalRaster technology, and Linotype-Hell's Diamond Screening, which limits the randomness of dot placement to the imagesetter grid (rather than a calculation for randomness).[6]

In the example above (50% tone), applying the rule of combinations, for one FM screen tint of 16x16=256 laser spots at tone value step 128 (corresponding to 50% tone), there are about 5.7687×10^{75} different possible bitmaps.[7] Actually, the 5.7687×10^{75} different bitmaps also include a large number of bitmaps that are not suitable for FM screening (like all laser spots arranged on the border or closed in at the center as in AM screening), but there are still plenty of possibilities to avoid a visible dot pattern.

An AM screen is specified by its screen ruling – lines per inch (lpi), and an FM screen is specified by the size of micro dots which is usually given in microns (μm, 10^{-6} m). The output micro dot size of the FM screen depends on the resolution of the output device. Because each FM dot is composed of a single laser spot or a matrix of laser spots, an FM micro dot is always proportional to the imagesetters' laser spot size (1x1, 2x2... etc., a matrix of laser spots).

For example, AGFA's FM screening system, known as CristalRaster, is using a 2x2 matrix of laser spots to generate FM micro dots. Because the laser spot size of a 2,400 dpi resolution imagesetter is 10.5µm and the CristalRaster FM micro dot is created by 2x2=4 laser spots, the size of the FM micro dot output from a 2,400 dpi imagesetter is 21µm, which is equivalent to a 1% dot of a 150-line screen. A 3,600 dpi resolution imagesetter produces a 14µm FM micro dot, which is about equivalent to a 1% dot of a 200-line screen.[8]

Dot Gain

One of the biggest problems of FM screens is its initial high dot gain. Dot gain is the dot area change during image transfer. It is the difference between film dot area (FDA) and printed dot area. Total dot gain is calculated from densitometer readings by using the Murray-Davies formula.[9] Excess dot gain can change the picture contrast and cause loss of detail in printing.

There are three major factors that are part of total dot gain. The first factor happens at the platemaking stage. For negative working plates, the light undercut increases the dot area on the plate. The second factor is the spread of the ink film (mechanical dot gain). The last factor is the light penetration occurring on the surface of the paper and trapped under the printed dot (optical dot gain).

Mechanical Dot Gain

Mechanical dot gain is the enlargement of the geometrical dot size on the substrate as compared to the dot size on film. It is the physical change of the dot size due to platemaking and ink film spread. Mechanical dot gain can be divided into two types: non-directional and directional dot gain.

Non-directional dot gain happens in both platemaking and printing stages. Because of the light undercut on the plate exposure, standardized negative working plates have a dot gain of about 3-4% dot area in the midtone, whereas positive working plates have a dot loss of about the same magnitude.[10] At the printing stage, fill-in occurs, and it depends on ink, paper, and printing pressure.

The directional dot gains are doubling and slur. Doubling is a micro-registration problem between printing units. Slur is the elongation of halftone dots caused by different surface speeds between two cylinders.

Optical Dot Gain

When a printed halftone is measured with a densitometer, it does not measure the geometrical (actual) area of coverage, but the reflected light. It is the optical effective area of ink coverage which is measured.[11] A part of the incident light penetrates into the paper between the dots at the unprinted points and is trapped under the dots during reflection. This absorbed light creates a shadow area around the dot (see figure 4). The result is that the dot appears optically larger.

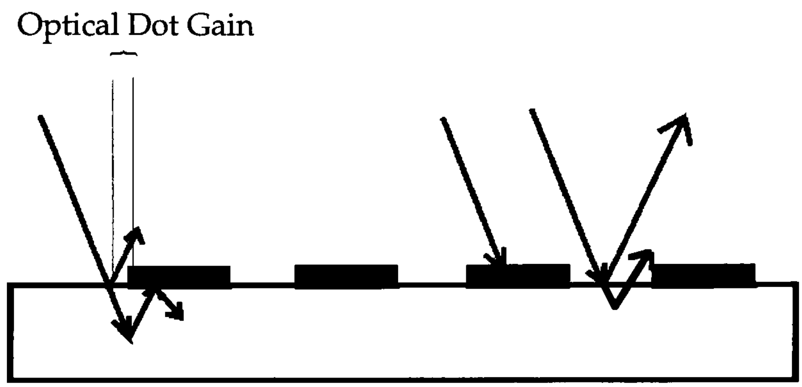


Figure 4. Optical dot gain is due to the effect of light entrapment underneath the dots

Dot gain (both optical and mechanical) always happens at the edge of a dot. The more edge a dot has the more dot gain can take place. Therefore, finer screen rulings have more dot gain than coarser screen rulings. Table 1 shows how those three factors affect the dot gain for different screen rulings.[12] Optical dot gain plays a major part of the total dot gain.

Dot Gain of midtone (50% film dot area) printed on coated paper:

	150-lpi	200-lpi	300-lpi
Negative Platemaking Undercut	3%	4%	6%
Printing Mechanical Dot Gain Optical Dot Gain	6% 15%	8% 19%	12% 23%
Total Dot Gain	24%	31%	41%

Table 1. Formation of dot gain for different screen rulings[12]

Border Zone Theory

A direct relationship between dot diameter, dot circumference and dot area has been established which is called the Border Zone Theory. It basically says that (1) dot gain occurs at the edge (border zone) of a dot, and (2) the assumption is made that the width of the border zone enlargement is the same for larger or small dots or even micro lines.[13] The longer border causes higher dot gain in both mechanical and optical ways.

According to the Border Zone Theory, fine spot size FM screens should have higher dot gain than AM screens, because fine spot size FM screens have longer border length per unit area than AM screens. For example, for the 25 percent tint, the total circumference of 1x1 FM micro dots is 6.1-times greater than the circumference of an AM dot (see figure 5).[15] The circumferencial difference between FM and AM dots will reduce when a larger FM micro dot is used, such as 2x2 or 4x4 FM micro dots.

Because there is no screen ruling for FM halftones, it is difficult to decide what spot size FM screen is equivalent to an AM screen. However, it is possible to characterize both AM and FM screens by the total border length per unit area on a given % film dot area. Since dot gain happens at the edge of a dot, more border length results in more dot gain. By comparing the border length difference between FM screens to a reference AM screen, we can learn more about the dot gain behaviors of FM screens. Therefore, it is possible to explain dot gain difference between AM and FM screens by using border length differences between them.

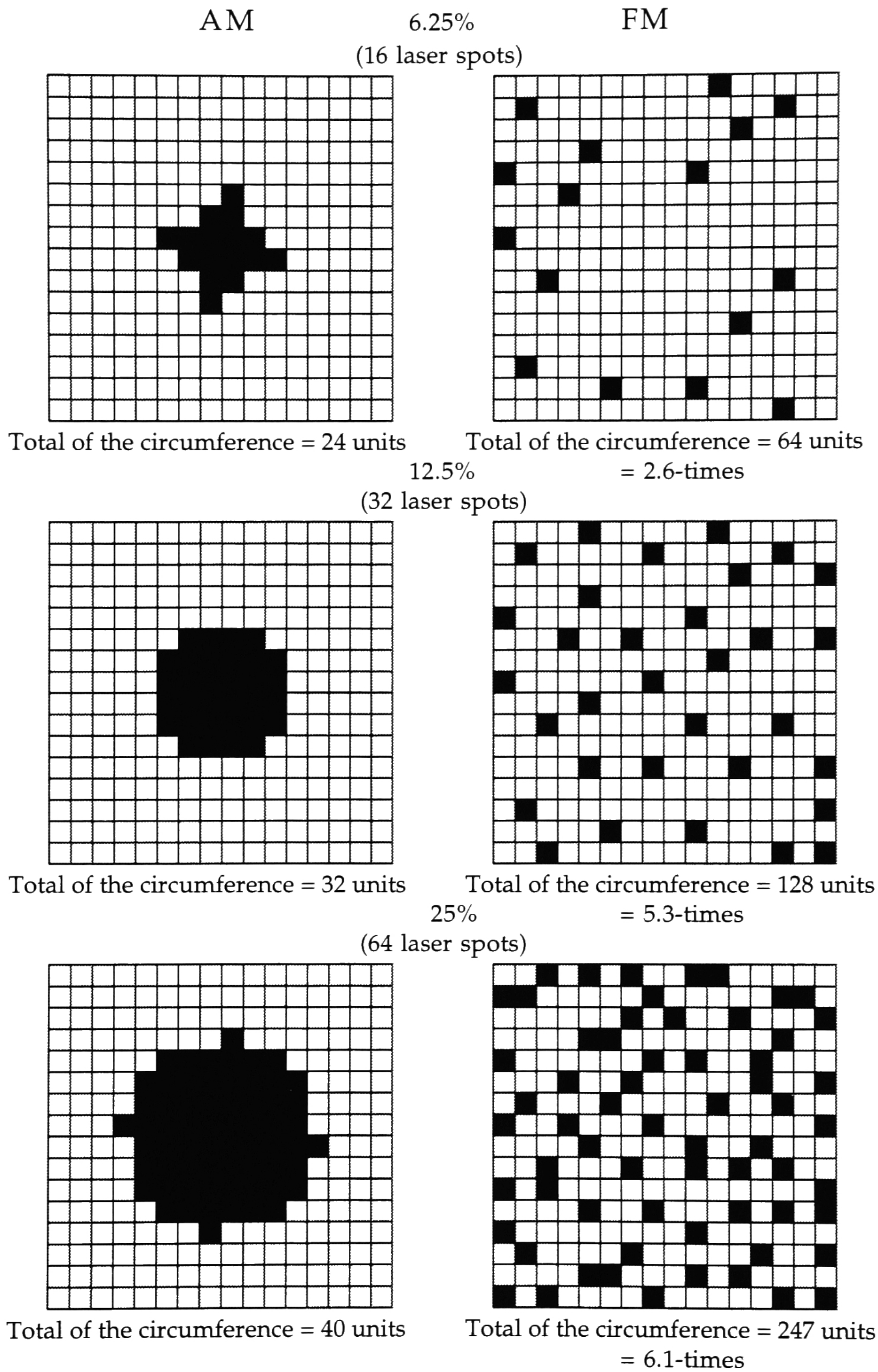


Figure 5. With identical steps (from top to bottom: 6.25%; 12.5% and 25%) the sum of the circumferential lines in the FM screening is 2.6; 5.3 and 6.1-times longer than in AM screening.[15]

Dot Gain Differences Between AM and FM Screens

Based on all the assumptions and tests above FM screens have higher dot gain than AM screens. The high dot gain of FM screened images have to be compensated in order to match the color of AM screened images. Figure 6 shows the dot gain difference of the magenta prints between 85-lpi AM screen and 42µm FM screen (UGRA Velvet Screen) printed on newsprint meeting the Specifications for Non-Heat Advertising Printing (SNAP).

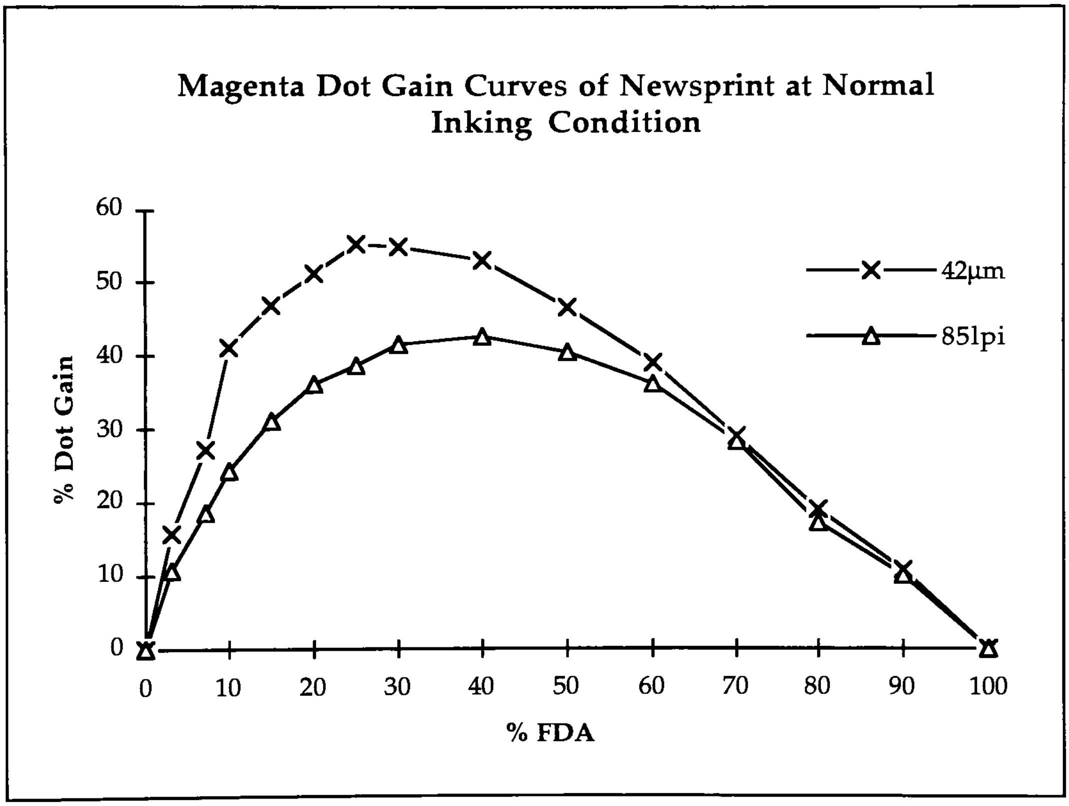


Figure 6. Dot gain curves of AM and FM screens printed on newsprint[16]

The major dot gain difference is in the quarter tone to midtone values. It can be explained by using the Border Zone Theory, the total border length of the FM screen in the lower tonal values is much longer than the AM screen. In the higher density areas because the FM micro dots start to have more linkage, the circumferencial differences between FM and AM dots are smaller. The three-quarter tone to solid areas have already plugged-in.

The Maximum Possible Dot Gains

There is a theoretical limit as to the maximum dot gain for a given % film dot. Because dot gain can at most fill in the space between dots, the maximum dot gain is equal to 100% minus the % film dot. This can be shown by drawing a forty-five degree line on the dot gain curve chart (see figure 7). Thus, the potential dot gain at 40% film dot area is greater than that of 50% film dot area.

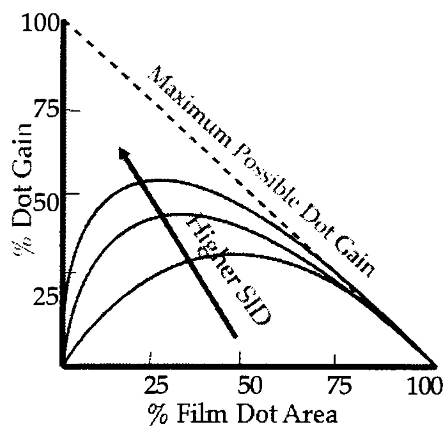


Figure 7. The trend of peak dot gain

Dot Gain vs. Solid Ink Density (SID)

There is a direct relationship between increased SID and dot gain. When SID increased, the shadow area starts to plug-in and the midtone area starts to fill-in. As the result, the dot gain curve skews upward the quarter tone area while the SID increased. Figure 7 shows the trend of peak dot gain.[17]

An FM screen test at RIT has shown that the 21µm FM screen (AGFA CristalRaster) has less dot gain variation than 150-lpi AM screen. The solid ink density was increased by 0.9 unit. The dot gain obtained with 21µm FM screen is only 6% higher in the middle tones (50% tone), while a conventional screen of 150-lpi shows an increase of 11%.

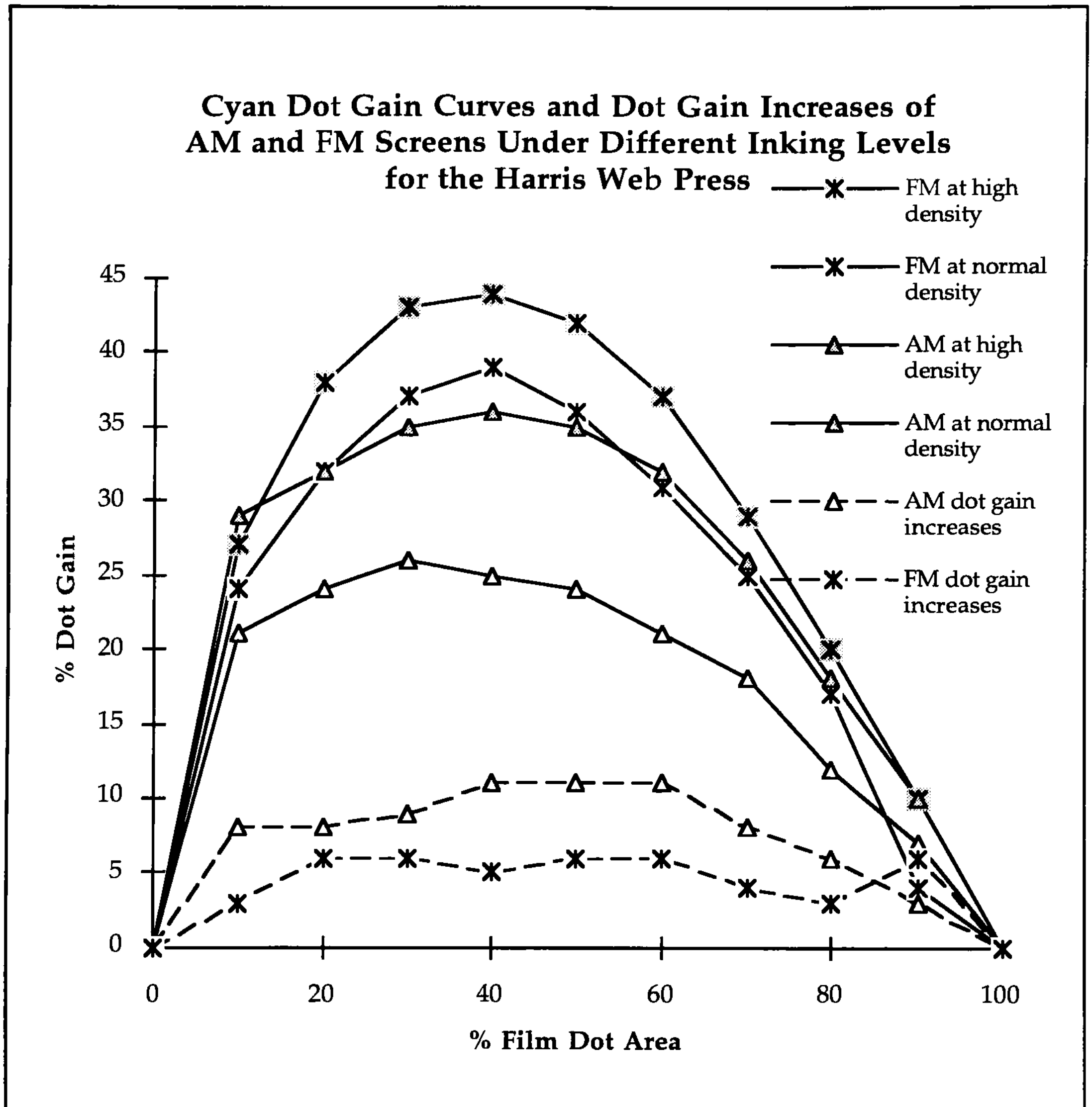


Figure 8. Dot gain curves and dot gain increases of the 150-lpi AM and 21µm FM screens under different inking levels for the Harris Web Press

The normal inking was printed to meet the SWOP printing conditions. For the high inking level, the cyan solid ink density was increased from 1.36 absolute density to 2.26 (see figure 8).[18] The test shows that the FM screen has more latitude to ink variation than the AM screen on the Harris web press.

The Proper Spot Size for Newsprint

What is the proper spot size for newsprint production? The resolution of the negative plate is about six to seven microns. The 30µm FM screen has been proven to be relatively trouble-free for the newspaper application.[19] UGRA recommends a spot size 20µm for offset printing on coated paper and 40µm for newspaper printing. For conventional screening, SNAP recommends 85 to 100-lpi screen as a general guideline. By using the UGRA Velvet Screen program, a 2400 dpi resolution imagesetter can generate 42µm FM screen easily, which contains 4x4=16 laser spots. The 42µm FM dot is slightly larger than 1% dot of 85-lpi AM screen. The 42µm FM spot size is often used because it gives the best result for newsprint.

Endnote for Chapter 2

1. Howard Fenton, "The New Screen Technology," Signature, May 1994, p.23.

2. Andy Thomas, "Screen Wars," British Printer, March 1994, p.17.

3. UGRA/FOGRA, "Velvet Screen Version 1.0 Instructions for Use," Edition of February 1994, p.3.

4. Erwin Widmer, Kurt Schläpfer, Veronika Humbel, and Serdar Persive, "The Benefit of Frequency Modulation Screening," TAGA Proceeding, 1992, p.28.

5. Karl Haller, "A Survey of The Latest Screening Methods," Newspaper Techniques, June 1993, p.11.

6. Ira Gold, "The promise of Stochastic Screening," Color Publish, July/August 1993, p.8.

7. Karl Haller, "A Survey of The Latest Screening Methods," Newspaper Techniques, June 1993, p.14.

8. John Lind, Vicki Stone, "Stochastic (Frequency-Modulated) Screening," GATF 1995 Technology Forecast, January 1995, p.7.

9. "Specifications Web Offset Publications," 1993, p.16.

10. Franz Sigg, "Test Target for Pressroom Applications," unpublished paper, February 1992, p.4.

11. William Sullivan, "Applied Densitometry," Gretag Color Control System, U.S.A., p.6.

12. Kurt Schläpfer, Erwin Widmer, "Are Fine Screens An Alternative To Frequency Modulation Screening," TAGA Proceeding, 1994, p.38.

13. Franz Sigg, "A Few Things About Microlines That Most People Do Not Know," TAGA Proceeding, 1988, p.439.

14. Same as 13.

15. "Can FM Screening Give Newspaper Gravure Quality?" Newspaper Techniques, April 1994, p.35.

16. Data collected from "RIT/KEPS PCS100 Color Management System and FM Newsprint Test Page," November 1994.

17. Robert Y. Chung and Li-Yi Ma, "Press Performance Comparison between AM and FM Screening," TAGA Proceeding, 1995.

18. Teerapong Laoharavee, "Optimizing Tone Reproduction for AM and FM Halftones to Print at Normal and High Density Levels," RIT student independent study, April 1995.

19. Waldemar Geuther, "Practical Experiences With Frequency-Modulated Screens," Newspaper Techniques, March 1995, p.29.

Chapter 3

Review of Literature

The Market of FM Screens

Over the past ten years there has been much talk about Frequency Modulated screening. Frequency modulated (FM) rastering was first introduced by the Technische Hochschule Darmstadt, Germany in 1983.[1] In 1986, Gerhard Fischer was granted a doctor's degree on his thesis: "The frequency modulated image composition – a contribution to the optimization of print quality." Because the limitation of the speed of computers and accuracy of output devices little had been printed. At the Sybold Seminar in Boston in April 1993, both Agfa and Linotype-Hell announced their version of FM raster products, CristalRaster and Diamond Screen respectively, FM or Stochastic screening became a new "buzz" word. It was discussed extensively in trade articles. Today, at least 17 FM screening products are available on the market.

In VuePoint 94, the fifth annual spring conference held in Virginia, the FM screening panel summary indicated that panel members are quite positive about the potential of FM screening. Roy Fisher from Dynagraf, Inc. estimates that up to 30% of his business may go this route in a few years.[2] A survey conducted by Publish & Production Executive magazine in April 1995 also shows: 4% of printers are using FM screening now and 26% printers plan to do so within 18 months.[3] Although FM screening has been praised for several advantages over conventional halftone screening, FM screening is not a well understood process from the press performance point of view by the graphic arts community.

Latitude of FM Printed Images

Andy Williams in his article "Frequency Modulated Screen for Newspaper" shows there is nothing extraordinary about FM printing. Generally, the normal production equipment and materials used for web-offset printing can be used for FM screened images. A checklist, as shown below, provides further detail:[4]

- — imagesetter capable of more than 1200 dpi resolution;
- — high-definition film with hard "dot" edge-density profiles and high density;
- — high resolution plates (capable of resolving 6μm or less); and
- — a reasonable surface to the newsprint.

Good results can be produced by using these standard materials and in normal production runs. Press settings remain the same. The performance of the plate with FM screens is unchanged. There is no need for extra press adjustment during the run. Despite the similarity of AM and FM printing, the appearance of FM images is less sensitive to inking change than conventional screening. But the article does not provide enough data to support this claim.

According to Paula Tognarelli, United Lithograph prepress manager, CristalRaster makes it possible to get up to color 60-percent faster than other processes and is especially efficient in working with gray tones.[5]

Several articles also show FM screening is a more stable printing process than conventional screening. Tests at UGRA have shown that, if the solid tone density is increased by 0.2 unit, the dot gain obtained with FM screens printed on coated paper is only 3 to 4% higher in the middle tone, while a conventional halftone screen of 150-lines shows an increase of 6%.[6] In a pilot study at RIT, we found very similar results to those reported by UGRA.

Tests also found that FM screening technology is extremely precise but unforgiving. Film must have high contrast and high resolution to provide a high level of reliability in contacting and platemaking.[7] The calibration of the laser intensity is extremely important for film exposure of FM screens. FM screening films require the highest level of care to avoid dust and accuracy of exposure especially in platemaking.

The IFRA research project on "Optimal Screen for Newspapers" samples both FM-screened and high resolution, conventionally-screened images for the quality comparison.[8] The newsprint test pages were printed by using three FM screens (21µm, 28µm, 30µm) and three AM screens (85-lpi, 150-lpi, 200-lpi). The findings point to a substantial increase in the quality of reproduced pictures in newspapers through the use of FM screening algorithms. The use of FM screening has improved the quality of printing on newsprint considerably. The FM screens produce the quality images that only high screen ruling AM screens achieved in the past.

Previous RIT Theses Study

In Kelly Laughlin's RIT master thesis, *An Investigation of Amplitude & Frequency Modulated Screening on Dot Gain and Variability,* he determined that a correlation does exist between screen ruling and dot gain, but little evidence was developed to support the idea that screening relates to variability. The test form was printed on a Harris M-1000 web press. Once the press was in a stable running condition, thirty samples were drawn every minute. His test shows that when all other factors are held constant, tonal scales printed with FM screens demonstrate higher average dot gain than scales printed with conventional AM screens except for the very fine AM screens (see table 2).[9] The test also shows FM screens provide a more stable process when compared to the conventional screens. FM screen variability seems somewhat lower than the 300 or 500-lpi AM screens. He explains this finding by using the Border Zone Theory, but there is no specific data that shows how FM border length differs from AM border length.

		Dot Gain Level					
Screen	% Dot Area	Avg.	Max.	Min.	Range	StDev	Var.
100 lpi	46.80	24.60	26.30	23.60	2.70	0.52	0.27
150 lpi	46.10	31.00	34.60	29.40	5.20	1.05	1.10
200 lpi	49.10	34.20	37.10	32.90	4.20	0.76	0.58
300 lpi	46.20	40.40	42.20	39.40	2.80	0.52	0.27
500 lpi	52.90	38.40	39.70	37.30	2.00	0.46	0.21
21 µm	52.20	39.30	40.10	38.90	1.20	0.25	0.06

Table 2. Average dot gain comparison between AM and FM screens found by Kelly Laughlin

In Justine E. Adamcewicz's RIT master thesis, *A Study on the Effects of Dot Gain, Print Contrast and Tone Reproduction as It Relates to Increased Solid Ink Density on Stochastically Screened Images Versus Conventionally Screened Images,* she evaluated the performance of FM and AM screened images.[10] The thesis is based on the same test run as Laughlin's thesis test run. At the end of the test run, she increased the ink setting four more levels. Each level was based on two LEDS increase on the inking control panel of the Harris M-1000 web press. Sixteen samples were pulled from each level of inking increase. The average solid ink density and average dot gain on 48% tint pitch of sixteen samples within each inking level were measured (see table 3). Her findings are: (1) the conventional screened images actually performed better than stochastically screened images because stochastic images actually experienced higher dot gain than conventional screened images in the 48% tint areas under each inking level; (2) although stochastic images undergo more dot gain than conventional screened images, the gain seems constant in spite of the increased inking.

	STD	1	2	3	4
Average SID	1.44	1.62	1.60	1.84	1.96
21μm FM Dot Gain	43%	44%	44%	46%	47%
150lpi AM Dot Gain	32%	35%	35%	40%	44%

Table 3: Average dot gain for magenta at 48% tint patch at five different inking levels found by Justine E. Adamcewicz

It appears that although there is more dot gain for the FM screen than the AM screen with normal inking (43% vs. 32%), the dot gain difference due to increased solid ink density is less for the FM screen (47%-43%=4%) than the

AM screen (44%-32%=12%). The experiment is limited only to increasing the solid ink density. There is no data for a decreased ink setting. In addition, the test results indicate that there is a large fluctuation of the solid ink density within the samples of one ink level (see table 4). The large density deviation within each ink level suggests that the samples were collected while the press was still not in equilibrium. Consequently, there is a large degree of noise inherent in the data. One needs to interpret the findings with some degree of reservation.

	STD	1	2	3	4
Average	1.44	1.62	1.60	1.84	1.96
Maximum	1.55	1.83	1.81	2.03	2.14
Minimum	1.33	1.36	1.39	1.60	1.78
Range	0.22	0.47	0.42	0.43	0.36

Table 4. Average solid ink density for magenta at five different inking levels in Justine E. Adamcewicz's thesis

In Teerapong Laoharavee's independent study, *Optimizing Tone Reproduction for AM and FM Halftones to Print at Normal and High Density Levels,* he used the Jonse type diagram to adjust tone reproduction of a normal image to the requirements of printing at the higher densities.[11] The press run was also conducted on the Harris M-1000 web press. The test images were printed in both 150-lpi AM and 21μm FM halftones. At the normal printing density (SWOP), the FM images were adjusted closely to the AM images. The press run shows that FM dot gain is more stable than AM dot gain when the solid ink density increased (see figure 8 at page 19).

Summary

Although studies reviewed in this chapter show FM screens seemed to have less dot gain variation than AM screens when solid ink density increased, there was no systematic test to indicate how color varies due to both increased and decreased solid ink densities. All three RIT studies were conducted on the same Harris M-1000 web press and printed on coated paper. There were no specific data to show how the Border Zone theory relates to the dot gain differences between AM and FM screens.

This study focused on two objectives: (1) how the border length on film dot area relates to the dot gain on press sheet; and (2) under newsprint production, how stable the FM halftone is on both low and high inking conditions.

Endnote for Chapter 3

1. Erwin Widmer, Kurt Schläpfer, Veronika Humbel, and Serdar Persive, "The Benefit of Frequency Modulation Screening," TAGA Proceeding, 1992, p.28.

2. Miles Southworth, "What's New," Quality Control Scanner, December 1994, p.1.

3. "1995 Prepress Survey: Goodbye Analog Workflows," Publishing & Production Executive, April 1995, p.42.

4. Andy Williams, "Frequency Modulated Screening for Newspapers," Newspaper Techniques, May 1994, p.45.

5. Howard Fenton, "The New Screening Technology," Signature, May 1994, p.24.

6. Kurt Schläpfer, Erwin Widmer, "Are Fine Screen An Alternative To Frequency Modulation Screening," TAGA Proceeding, 1994, p.38.

7. Linotype-Hell, "Diamond Screening User's Guide," version September 1993, p. 3-14.

8. Same as 4.

9. Kelly Laughlin, "An Investigation of Amplitude & Frequency Modulated Screening on Dot Gain and Variability," RIT Master thesis, May 1994.

10. Justine E. Adamcewicz, "A Study on the Effects of Dot Gain, Print Contrast and Tone Reproduction as It Relates to Increased Solid Ink Density on Stochastically Screened Images Versus Conventionally Screened Images," RIT Master thesis, May 1994.

11. Teerapong Laoharavee, "Optimizing Tone Reproduction for AM and FM Halftones to Print at Normal and High Density Levels," RIT student independent study, April 1995.

Chapter 4

Hypothesis

The fineness of AM screens can be described by indicating the screen rulings, and the fineness of FM screens is measured by the size of the micro dots. Because there is no screen ruling for FM halftones, it is difficult to decide what spot size an FM screen is equivalent to an AM screen. However, it is possible to characterize both AM and FM screen tints by the border length per unit area. Since dot gain happens at the edge of a dot, more border length results in more dot gain. By comparing the border length difference between FM screens to a reference AM screen, more information can be learned about the printing behavior of FM screens.

This study was to answer two major questions: (1) What is the relationship between the border length ratio on film dot area of various FM screens to a reference AM screen and the maximum dot gain difference between them? (2) How does the color of FM and AM images react to ink variations on both low and high inking conditions for newsprint production?

The Specifications for Non-Heat Advertising Printing (SNAP) recommends 85-lpi AM screen for newsprint. UGRA recommends 40μm FM halftone for newspaper printing. Therefore, in this study the 85-lpi AM screen was used as the reference screen. The 42μm FM screen (UGRA Velvet screen) was used for the color stability test.

Hypothesis

Based on all the questions above, three hypotheses were developed for this study. These hypotheses were written in the null form. If the hypothesis is rejected than the alternative hypothesis can be accepted.

Hypothesis 1: There is no significant correlation between the maximum border length ratio of various FM halftones to a reference 85-lpi AM halftone and the corresponding maximum dot gain difference between the reference 85-lpi AM and FM halftones.

Hypothesis 2: There is no significant color variation between 42μm FM screened image and 85-lpi AM screened image when solid ink densities of the newsprint are increased by 0.20 relative to SNAP's aim point.

Hypothesis 3: There is no significant color variation between 42μm FM screened image and 85-lpi AM screened image when solid ink densities of the newsprint are decreased by 0.20 relative to SNAP's aim point.

Limitation and Delimitation

1. Assume that the lens on the microscope and the CCD video are sufficient to capture enough dots on both FM and AM halftones for the border length calculation.
2. The 85-lpi AM screens were output using AGFA Balanced Screening.

3. The FM spot sizes of 21μm, 32μm, 42μm, 53μm, 64μm, 84μm were output using Velvet Screen v.1.5 software.
4. The test run was conducted on the Rockwell positive-feed keyless Newsliner newsprint press.

Chapter 5

Methodology

This study focused on the press performance of the FM halftone printing on the newsprint. The objectives of this research were: (1) how does the border length on film dot area relate to the dot gain on the press sheet; (2) how stable is the FM screen in newsprint production. The experimental press run was conducted on the Rockwell positive-feed keyless Newsliner newsprint press.

The Specifications for Non-Heat Advertising Printing (SNAP) recommends 85-lpi AM screen for newsprint. UGRA recommends 40µm FM halftone for newspaper printing.[1] Therefore, in this study the 85-lpi AM screen (AGFA Balanced Screening) was used as the reference AM screen. The 42µm FM screen (UGRA Velvet screen) was used for the color stability test.

Test Form Design

The test form of this experiment consists of the following elements: 1) 85-lpi AM screen color control bar (for press control); 2) UGRA wedges (for plate exposure control); 3) IT8.7/3 basic color set at both 100-lpi, 85-lpi AM and 42µm compensated FM screens (for color measurement); and 4) IT8.7/3 basic color set at 21µm, 32µm, 42µm, 53µm, 64µm, 84µm FM screens (without dot gain compensation for the test of hypothesis one); 5) Pictorial images at both

85-lpi AM and 42µm FM screens (for visual comparison). Figure 9 is the layout of the test form.

Figure 9. Test form layout. (1) 85-lpi Color control bar; (2) UGRA wedge; (3) IT8.7/3 basic color set at 100-lpi, 85-lpi, and compensated 42µm; (4) IT8.7/3 basic color sets (scales only) at 21µm, 32µm, 42µm, 53µm, 64µm, 84µm (uncompensated); (5) Pictorial images; (6) Pixel Dot target; (7) Page description text

Equipment and Materials and Press Run Specifications

Prepress:

Computer	: PCS100 Image Station (Quadra 950)
Monitor	: Apple 21″ (P22 phosphor set)
Device Color Profile	: Newsprint Litho AD (260 TAC, 30% GCR)
Screen	: AM – 85-lpi AGFA Balanced Screen FM – 42µm UGRA Velvet Screen
Software	: QuarkXpress 3.31, Photoshop 2.5.1, UGRA Velvet Screen v. 1.5
Imagesetter	: AGFA SelectSet 5000
Film	: AGFA Alliance Recording HN

Press:

Press	: Rockwell positive-feed keyless Newsliner
Paper	: Weyerhaeuser Lightweight Domestic, 27.7 g/m^2, 28″ width
Plate	: 3M Viking
Plate Exposure	: Solid step 3 at UGRA wedge
Ink	: Black–Flint low rub oil base Color–U.S. Soy Adlitho ink
Ink-Down Sequence	: CMYK
Printing Speed	: 30,000 impression per hour
Printing Specifications	: Specifications For Non-Heat Advertising Printing (SNAP)

Experimental Procedures and Data Collection

Border length and dot gain measurement

The first part of the experiment was to test the first hypothesis. It was formulated to find out the relationship between the total border length ratio of different spot size FM screens to a reference 85-lpi AM screen and the maximum dot gain difference between them. The film was output using AGFA Selectset 5000 imagesetter, and the press sheet samples were collected at SNAP printing conditions.

1. Total Border length on film

In this research, the steps of scales of AM and FM screened films were captured using a video microscope and analyzed using Imagelab™ Image Analyzing software. The software captured the CCD video image into a 512x464 pixels image. Figure 10 will show the images of 85-lpi AM and 42μm FM screens at 50% tint (see appendix B). The total border length was calculated by the number of pixels along the borders of all dots within a captured image.

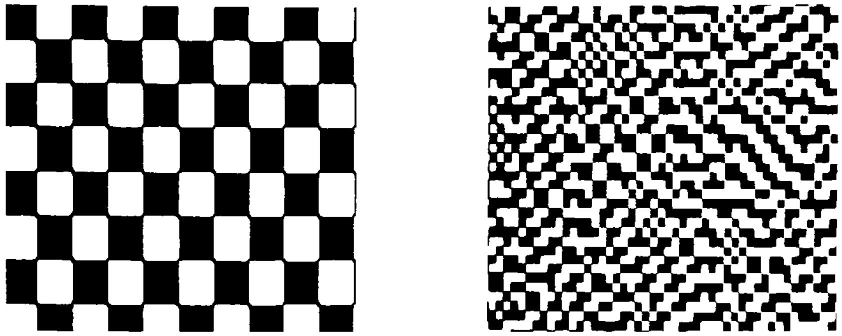


Figure 10. The enlarged AM (left) and FM (right) images captured by the CCD video (50 % film dot area)

2. Dot gain measurement on press sheet

An X-Rite 418 densitometer was used for the density measurements of the press sheet. The spectral response is status-T and the geometry of instrument is 0/45 as defined in ANSI CGATS.4 document. The dot gain was calculated using the Murray-Davies equation:

$$\%\text{Dot Gain} = ((1-10^{-(Dt-Dp)})/(1-10^{-(Ds-Dp)})) \times 100\% - \%\text{ Film Dot Area}$$

Ds is density of the solid;
Dt is density of the tint;
Dp is density of the paper.[2]

3. Plotting the graphs

The total border length of FM and reference 85-lpi AM screens against their dot gain were plotted for further analysis. Based on much discussion, it was decided to use the border length and the dot gain of the 85-lpi AM screen as a reference to study the FM screens' characteristics.

4. Statistical analysis

The data of the total border length and dot gain are too complex to interpret. Based on the reference 85-lpi AM screen, the maximum border length ratio and the maximum dot gain difference were used to interpret the relationship between total border length and dot gain. A dot gain difference can be determined by mapping the maximum total border length ratio from the chart. A total border length ratio can also be derived by mapping the maximum dot gain difference from the chart.

Base on the experimental data, two sets of data were founded. A question that must be answer is, "Do the two sets of data essentially describe the same phenomenon?" In other words, can we predict the maximum dot gain difference from the maximum total border length ratio, and vice versa?

To test the first hypothesis formulated in the previous chapter, Fisher's transformation was used to compare these two correlation coefficients. The significance level of $\alpha = 0.05$ was used to test whether the correlation is the same for both populations. The resulting transformed value, z, was used to determine the relationship between these two correlation coefficients.[3]

Color variation of FM and AM screens under five inking levels

The second part of the experiment was to test the second and the third hypotheses. There are three important considerations in carrying out the experimental procedures. First, FM images must be compensated for dot gain so that AM and FM reproduction have a similar appearance. Second, the inking must be uniform for AM and FM images. Third, a wide range of inking variations are tested. To do so, the experimental procedures are further explained with the following paragraphs.

1. FM dot gain compensation in prepress

All pictorial images were prepared using the KEPS PCS100 Color Management System. This system contains a newsprint device color profile that is used by the newspaper industry to produce quality images for AM newsprint.[4] The transfer curve of figure 11 was applied to the FM screen images to compensate for dot gain. This transfer curve was derived by using the technique of the Jones Type diagram.[5] Data were collected from "RIT/KEPS PCS100 Color Management System and FM Newsprint Test Page" which was printed in November 1994 at RIT (see appendix A).

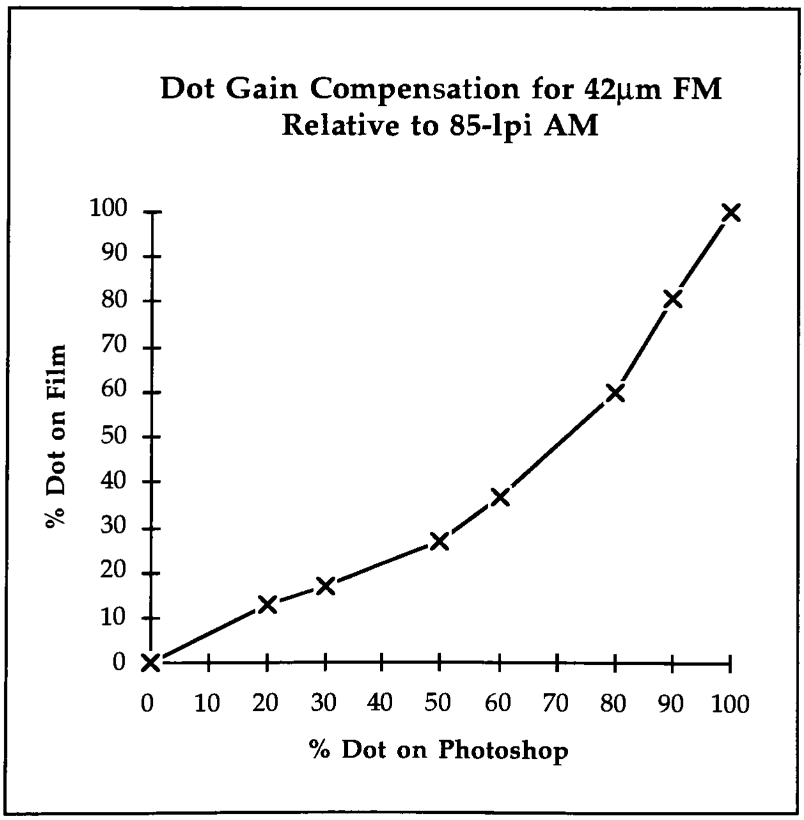


Figure 11. Transfer curve derived from plot press run

2. Uniform inking between AM and FM reproduction

Uniform inking between AM and FM images can best be assured through layout and imposition. Instead of placing the IT8.7/3 color block side by side, it was placed in line with each other on the press sheet. The positive-feed keyless feature of the Newsliner newspaper offset press further assures the uniformity requirement.

3. Determining inking variations

In order to observe color differences due to inking changes, a wide inking variation was necessary. Typical density variations which are acceptable, according to SNAP, is +/- 0.05. In this experiment, the range of density variation was set at +/- 0.20.

There were five levels of inking in this experiment, i.e., two inking levels lowered and two inking levels increased over the normal inking condition. The normal inking condition was set to conform to SNAP specifications. Table 5 shows the target densities of the five inking levels.

Inking	C	M	Y	K
Normal	0.93	0.93	0.88	1.08
Low 1	0.83	0.83	0.78	0.98
Low 2	0.73	0.73	0.68	0.88
High 1	1.03	1.03	0.98	1.18
High 2	1.13	1.13	1.08	1.28

Table 5. Target density values of five inking levels

4. Sample collection

After the press has reached its equilibrium for each inking level, press sheet samples were collected at every thirty seconds. Twenty press sheet samples were collected within ten minutes at each inking level. To assess the average colorimetric values at each inking level, only five samples, labeled as #1, #5, #10, #15, and #20, were measured.

5. Color measurement

The IT8.7/3 basic color set target containing 182 color patches in the press sheet was measured with an X-Rite 938 spectrodensitometer. The 85-lpi AM and compensated 42µm FM screened targets were measured at all samples. Colorimetric data (D50 illuminant and 2 degree observer) which conform ANSI CGATS.5 were collected.[6]

6. Data analysis

To assess color differences due to inking change, colorimetric values of the AM IT8.7/3 targets at normal inking were used as the reference for calculating the AM screen's color variations between inking levels. Similarly, the FM IT8.7/3 targets at normal inking were used as the reference for calculating the FM screen's color variations between inking levels. The final color difference was the average of the color difference of 182 color patches expressed in ΔE term.

Endnote for Chapter 5

1. UGRA/FOGRA, "Velvet Screen Version 1.5 Instructions for Use," Edition of February 1995.

2. "Graphic technology–Graphic arts reflection densitometry measurements-Terminology, equations, image elements and procedures," ANSI CGATS.4 - 1993.

3. Professor Hubert Wood, interview by author, Center for Quality and Applied Statistics, College of Engineering, Rochester Institute of Technology, Rochester, New York, September, 1996.

4. Kodak Electronic Printing Systems, "PCS100 Software User's Guide," Version 2.0.

5. Robert Y. Chung and Li-Yi Ma, "Press Performance Comparison between AM and FM Screening," TAGA Proceeding, 1995, p.323.

6. "Graphic technology–Spectral measurement and colorimetric computation for graphic arts images," ANSI CGATS.5 - 1993.

Chapter 6

The Results

Press Run Assessment

Table 6 shows the target densities and the average solid ink density of 20 samples at each inking level. This table helps to answer if the press run conforms to the target densities. An important observation is that discrepancies between the target density and the measured density are small, i.e., less than 0.05 with the exception of high inking levels (see appendix C). The density differences between the target and the high inking level were mainly caused by two factors: the ink dryback and the press control limit at higher inking levels.

	Low2		Low1		Normal		High1		High2	
	Target	Avg.	Target	Avg.	Target	Avg.	Target	Avg.	Target	Avg.
C	0.73	0.71	0.83	0.83	0.93	0.90	1.03	0.98	1.13	1.07
M	0.73	0.71	0.83	0.82	0.93	0.89	1.03	0.98	1.13	1.05
Y	0.68	0.67	0.78	0.74	0.88	0.82	0.98	0.91	1.08	0.97
K	0.88	0.87	0.98	0.96	1.08	1.06	1.18	1.09	1.28	1.17

Table 6. Target and average solid ink densities of each inking level

Total Border Length vs. Dot Gain

To examine the relationship between border length on film and dot gain on the press sheet for AM and FM screens, the following graphical analysis will show the relationship between border length and % film dot area; and the relationship between dot gain and % film dot area. A four-quadrant diagram was then used to derive a graphical relationship between total border length and dot gain.

Total border length vs. film dot area

The steps of scales of AM and FM screened films were captured using the video microscope and analyzed using Imagelab™ Image Analyzing software. The software captured the CCD video image into a 512x464 pixels image. The total border length was calculated by the number of pixels along the borders of all dots within a captured picture frame.

Based on the experimental data, figure 12 shows the total border length of a number of FM screens and two AM screens on film (see appendix D). The FM screen's microdot ranges from 21μm to 84μm. The two AM screens are 85 and 100-lpi respectively.

The graph shows that (1) border length is a function of % film dot area; (2) the maximum border length falls near the 50% film dot area region; (3) because the border length is peaked at the midtone, the border length vs. % film dot area curve is symmetric; (4) the smaller the microdot, the longer the border length. It is also important to point out that the coarsest FM (84μm) has longer border length than the two AM screens tested.

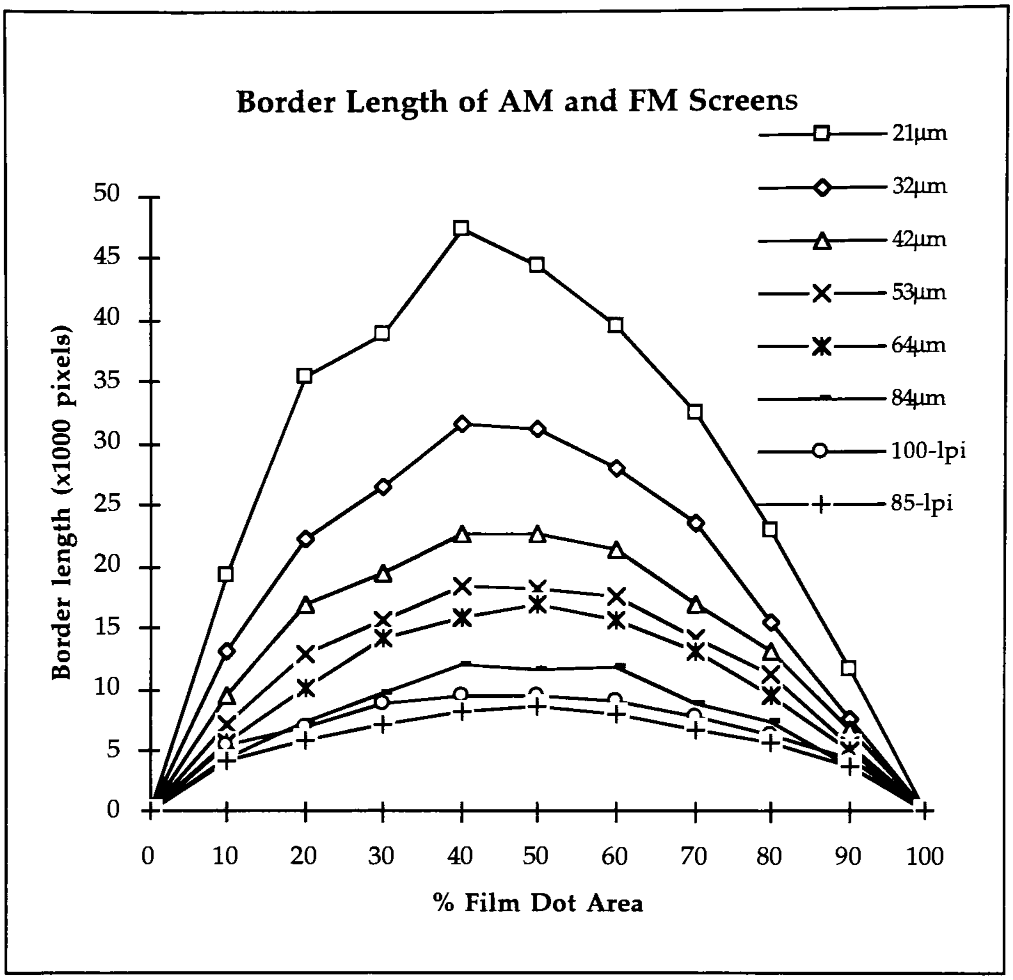


Figure 12. Border length of FM and AM screens on film

Dot gain vs. film dot area

Similar to some of the findings discussed in figure 12, figure 13 shows (1) dot gain is a function of % film dot area; (2) the smaller the microdot, the larger the dot gain; and (3) the coarsest FM (84μm) has larger dot gain than the two AM screens tested (see appendix E).

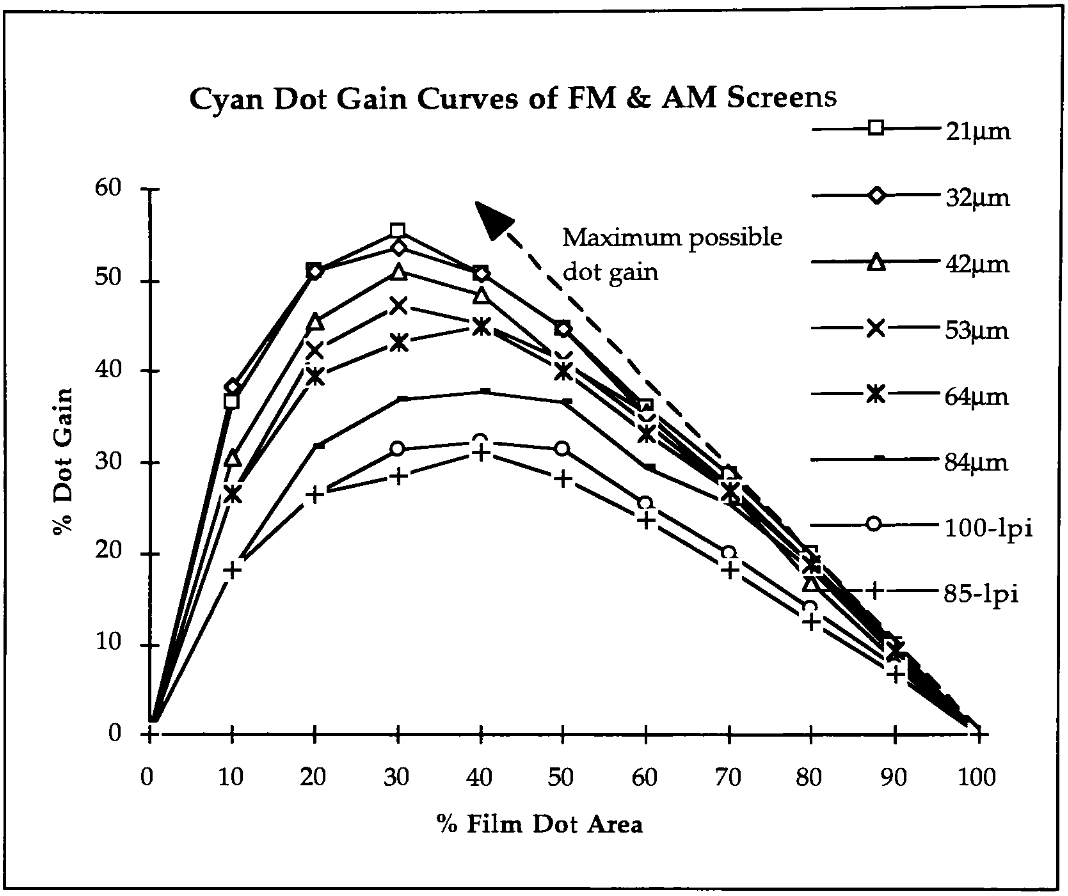


Figure 13. Cyan dot gain curves of various spot sized FM and 85-lpi AM

What is different in figure 13 from figure 12 is that there is no symmetry between the dot gain vs. film dot area curve. The largest dot gain of a small microdot FM screen falls closer to 30% film dot area instead of at 50%.

Total Border length vs. dot gain

To derive the relationship between total border length and dot gain, a graphic technique, similar to the Jones Type diagram, was used (see figure 14). In this graph, dot gain curves were placed in the first quadrant; and border length curves were placed in the second quadrant. By applying a straight-line transfer curve in the fourth quadrant, the border length vs. dot gain curves were derived in the third quadrant.

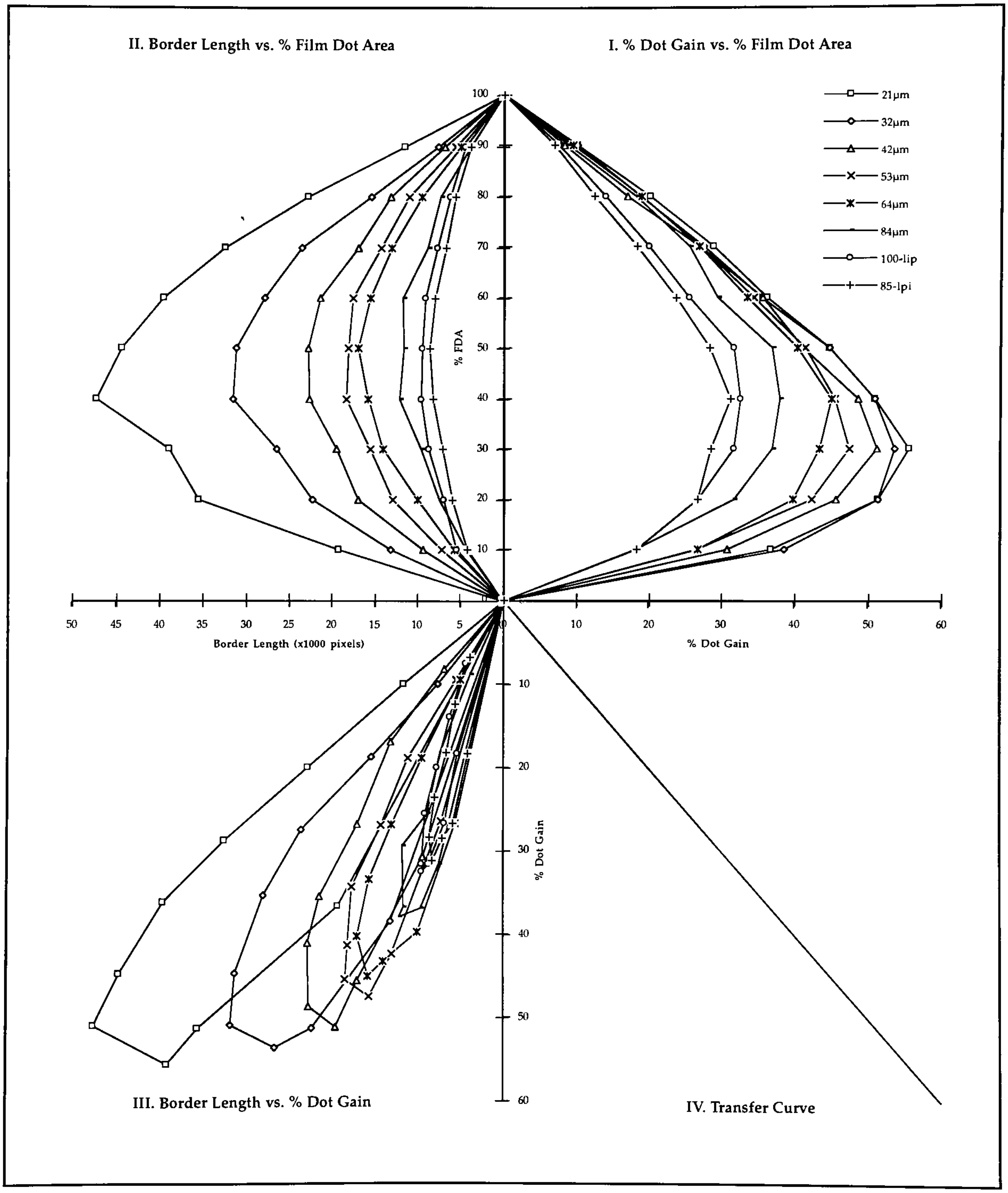


Figure 14. The relationship between border length and dot gain (cyan normal inking)

As can be seen in figure 14, the curves of border length vs. dot gain are all in the form of loops. The size of the loop depends on the size of the microdot and the asymmetry of the dot gain vs. film dot area curves. This is a clear indication that border length is not linearly related to dot gain. For example, for every border length of a halftone, there are two dot gain responses with the exception of the maximum border length. It appears that the maximum dot gain occurs at the tip of the loop.

Further analysis of border length vs. dot gain

Figure 14 is too complex to be useful to predict dot gain based on border length measurement. It is desirable if the analysis can be simplified. Based on much discussion, it was decided to use the border length and the dot gain of the 85-lpi AM screen as a reference to study other screening characteristics.

To implement the above approach, two new terms, border length ratio and dot gain difference, are defined. To be specific, border length ratio is the ratio of the border length of an FM screen to that of the 85-lpi AM screen at a given % film dot area. Dot gain difference is the difference of the dot gain between an FM screen and the 85-lpi AM screen at a given % film dot area. Table 7 is the example of how border length ratio and dot gain difference are derived.

If one is to describe the border length ratio of a halftone screen, it is desirable that the description of the screen should be made by its maximum border length ratio. This is also true for describing the dot gain difference. A dot gain difference can be determined by mapping the maximum border length ratio from the chart. A border length ratio can also be derived by mapping the maximum dot gain difference from the chart.

% FDA	0	10	20	30	40	50	60	70	80	90	100
21µm Border Length	0	19338	35493	38937	47347	44496	39555	32476	22830	11593	0
85-lpiBorder Length	0	4157	5939	7151	8244	8647	7959	6676	5607	3825	0
Border Length Ratio (21µm / 85-lpi)	n/a	4.65	5.98	5.45	5.74	5.15	4.97	4.86	4.07	3.03	n/a
21µm Dot Gain	0	36.65	51.23	55.51	50.78	44.66	36.09	28.76	20.00	10.00	0
85-lpi Dot Gain	0	18.28	26.65	28.52	31.23	28.35	23.58	18.24	12.39	6.78	0
Dot Gain Difference (21µm — 85-lpi)	0	18.37	24.58	26.98	19.55	16.31	12.51	10.52	7.61	3.22	0

Table 7. Border length ratio and dot gain difference between 21µm FM and 85-lpi AM screens

Using table 7 as an example, the maximum border length ratio of the 21µm FM is 5.98 (shaded) with a corresponding to dot gain difference of 24.58%. However, if we begin with the maximum dot gain difference, we will find, in table 7, that the maximum dot gain difference is 26.98% (shaded) which corresponds to the border length ratio of 5.45 (see appendix F).

Based on the experimental data, two sets of data were generated (figure 15). The first data set was derived from the maximum border length ratio between various screening conditions. The second data set was derived from the maximum dot gain difference. Both sets of data relate AM and FM screening together by means of border length ratio. A question that must be answer is, "Do the two sets of data essentially describe the same phenomenon?" In other words, can we predict the maximum dot gain difference from the maximum border length ratio, and vice versa?

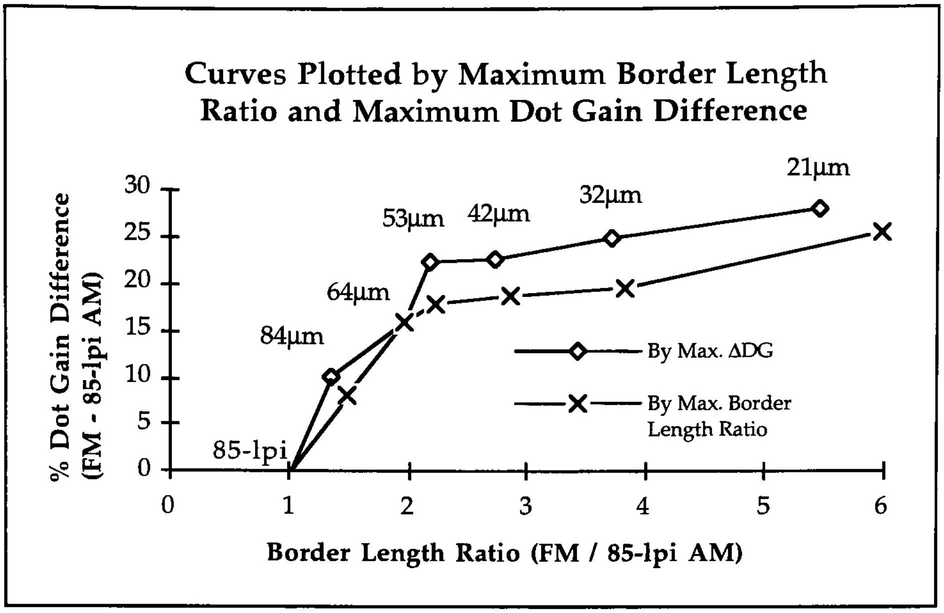


Figure 15. The graph of the maximum border length ratio and the maximum dot gain difference

Statistical analysis was performed to determine whether the two sets of data were the same. Correlation coefficients were calculated between maximum border length ratio and maximum dot gain difference of the two sets of data. Fisher's transformation was used to compare the difference between these two correlation coefficients (see appendix G). The significance level of α = 0.05 was used. The results show that there is no significant difference between the two correlation coefficients.

To summarize, the experimental finding and statistical analysis suggest that (1) the higher the border length ratio, the higher the dot gain of the screen in question; (2) high dot gain difference occurs at border length ratios of 2.5 or less, the increase of dot gain difference change reduces when the border length ratio is greater than 3.0; and (2) the maximum border length ratio for a given screen is where the maximum dot gain difference occurs. Thus, hypothesis #1 was rejected.

Changes in Solid Ink Density vs. Color Variation

Color variations due to inking change were analyzed by comparing color differences of a given inking to its normal inking. At the normal condition the average color difference for the IT.8.3/7 targets between 85-lpi AM and compensated 42μm FM is 2.03 ΔE (see appendix H). It shows the transfer curve works well, and the color differences are small.

For the AM inking series, the 85-lpi IT8.7/3 target printed at the normal inking condition was its reference point. For the FM inking series, the compensated 42μm FM IT8.7/3 target printed at the normal inking condition was its reference point. Table 8 shows the color variations of the 42μm FM and 85-lpi AM screens under different inking levels.

	ΔE(N-L2)	ΔE(N-L1)	ΔE(N-N)	ΔE(N-H1)	ΔE(N-H2)
AM-85 lpi	7.88	3.30	0	3.17	6.12
FM-42 μm	8.29	3.40	0	2.94	5.51

Table 8. Color variations of FM and AM screens for different inking levels

Figure 16 is a graphic depiction of the color variation of FM and AM screens due to the inking variations. By observation, we can see that (1) the magnitude of ΔE variation is proportional to the inking change, and (2) the closeness of the two lines indicates that the compensated 42μm FM has the same color variation (ΔE) as 85-lpi AM in both increased and decreased inking levels. In all cases, the color variation differences between 42μm FM and 85-lpi AM halftones over a wide range of inking variation is less than 1ΔE which is not noticeable.

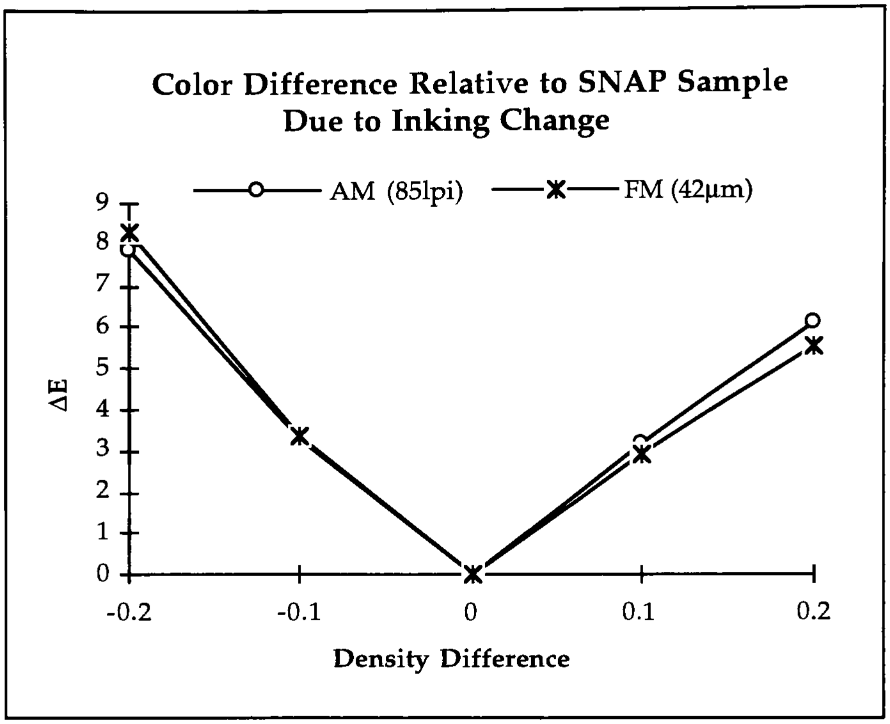


Figure 16. Color variations of FM and AM screens under five inking levels

Based on the above finding, this research failed to reject both hypothesis #2 and #3 which state that there is no significant color variation between FM and AM screening when solid ink densities of the newspaper press are increased or decreased.

Chapter 7

Summary and Conclusion

The first part of the experiment investigated if there is a relationship between the maximum border length ratio of FM screens to a reference AM screen and the maximum dot gain difference between them. The results show that the higher the border length, the higher the dot gain of the screen in question. In addition, the maximum border length ratio for a given screen is where the maximum dot gain difference occurs.

The second part of the experiment investigated if there is significant color variation between FM and AM screening when solid ink densities are varied. The results show that there is no significant color variation between AM and FM screening over a wide range of solid ink density variation.

The above finding is not in agreement with previous studies indicating that FM screens have higher latitude to the inking variation. A possible explanation to the discrepancy is that newsprint was used in this experiment instead of coated paper.

Conclusions of the Hypotheses

From the test results, the following are the conclusions of the hypotheses:

Hypothesis 1: There is no significant correlation between the maximum border length ratio of various FM halftones to a reference 85-lpi AM halftone and the corresponding maximum dot gain difference between the reference 85-lpi AM and FM halftones.

Rejected

Hypothesis 2: There is no significant color variation between 42μm FM screened image and 85-lpi AM screened image when solid ink densities of the newsprint are increased by 0.20 relative to SNAP's aim point.

Fail to reject

Hypothesis 3: There is no significant color variation between 42μm FM screened image and 85-lpi AM screened image when solid ink densities of the newsprint are decreased by 0.20 relative to SNAP's aim point.

Fail to reject

Recommendation for Further Study

(1) This study was only conducted under one newsprint condition. It might be interesting to have a similar systematic test under the SWOP printing conditions. Under the SWOP printing condition, the solid ink densities are higher and can have larger inking variations.

(2) The results of this study show the maximum total border length ratio can be used for predicting the maximum dot gain difference between FM and AM screens. As yet, the data present in this research are not enough to build a model to indicate how much is the maximum dot gain difference by using the maximum border length ratio. If the magnitude of the maximum dot gain difference between FM and a reference AM screens can be defined, the transfer curve of the FM screen relative to the reference AM screen can be derived from the information of the border length on film.

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Appendices

Appendix A

Appendix A

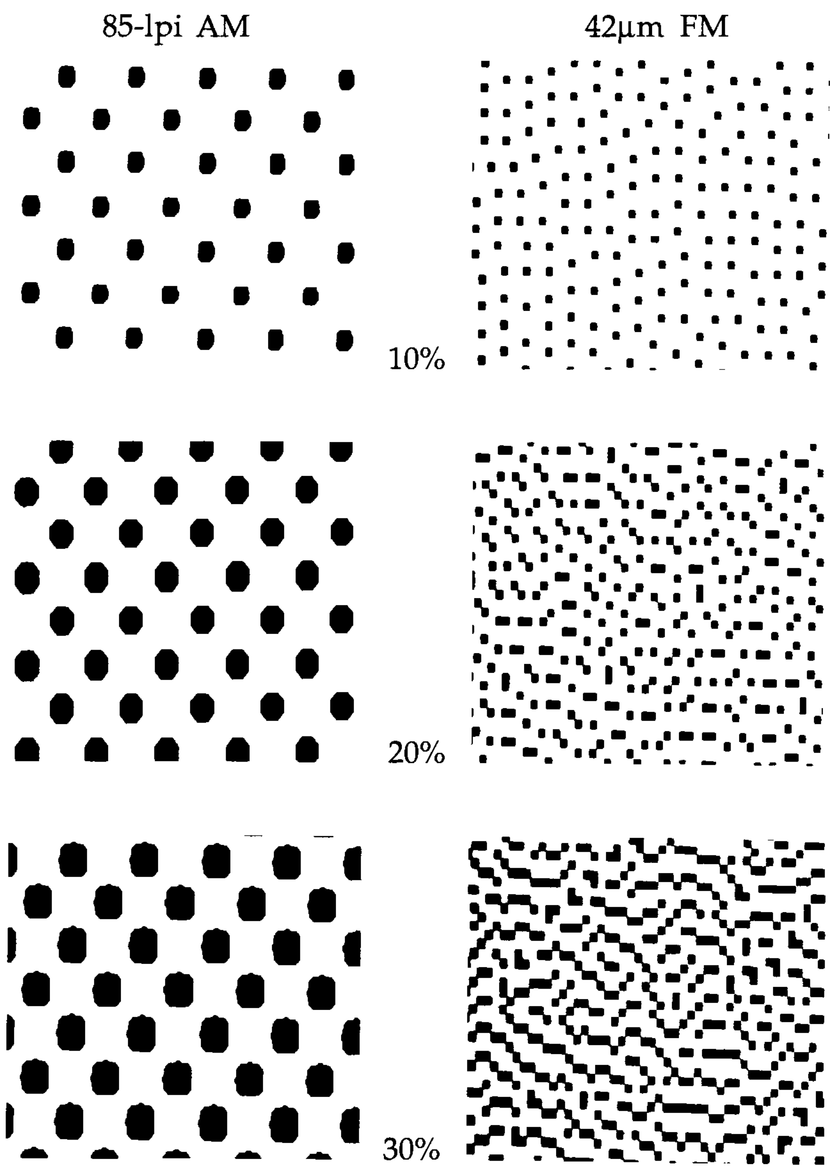
Table A1. The densities and dot gain data of 85-lpi AM and 42μm FM screens collected from "RIT/KEPS PCS100 CMS Newsprint test Page."

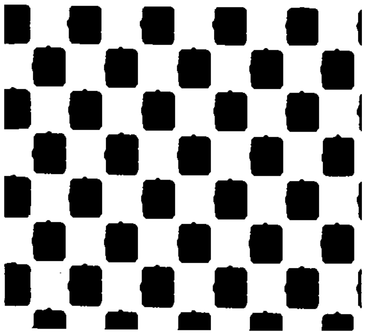
	85-lpi		42μm	
% FDA	Density	%Dot Gain	Density	%Dot Gain
100	0.71	0%	0.72	0%
90	0.71	10%	0.72	10%
80	0.68	18%	0.69	18%
70	0.66	27%	0.69	28%
60	0.63	35%	0.69	38%
50	0.54	38%	0.65	46%
40	0.46	41%	0.60	53%
30	0.35	39%	0.50	54%
25	0.30	37%	0.45	55%
20	0.24	33%	0.37	51%
15	0.19	29%	0.30	47%
10	0.14	24%	0.23	41%
7	0.10	19%	0.14	27%
3	0.06	13%	0.07	15%
0	0	0%	0	0%

Appendix B

Appendix B

File images of 42µm FM and 85-lpi AM screens.





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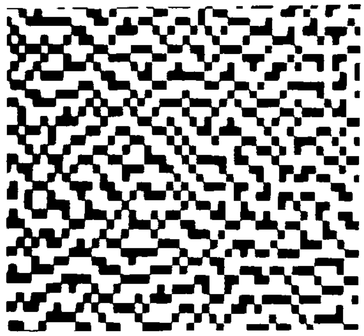

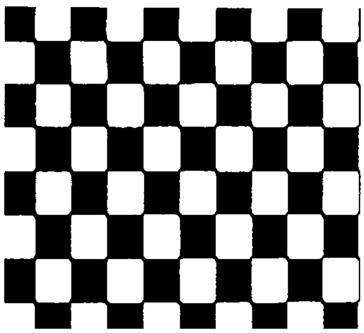

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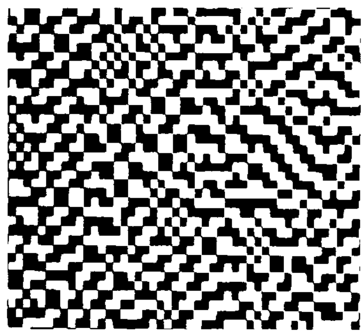

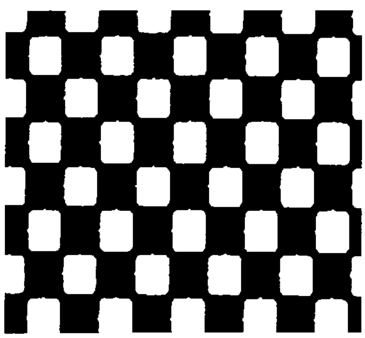

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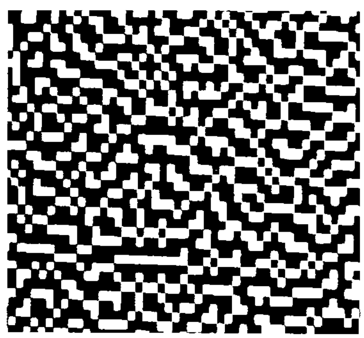

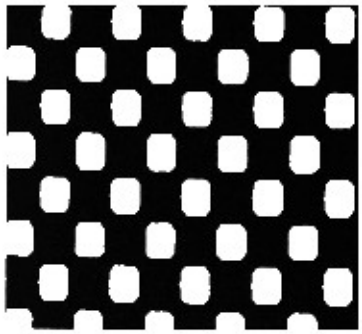

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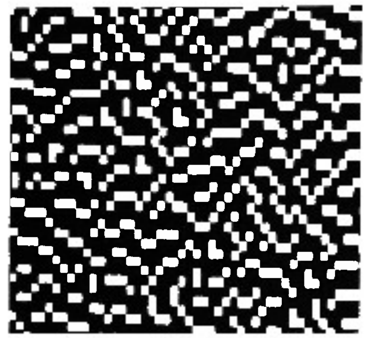

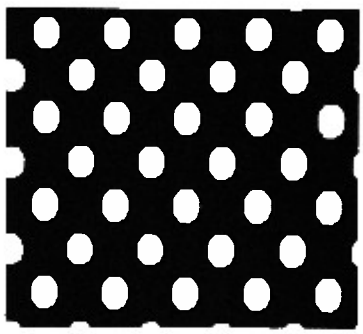

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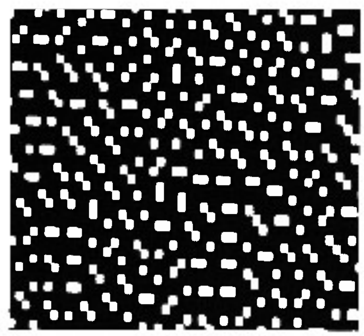
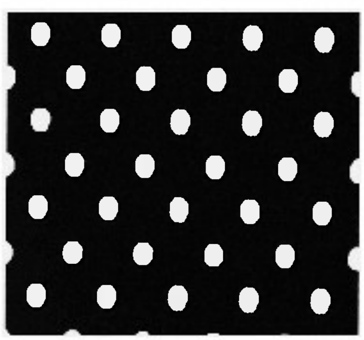
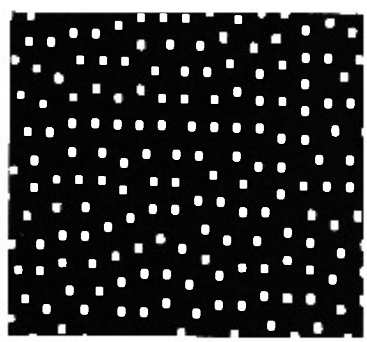




90%



Appendix C

Appendix C

Table C1. Solid ink densities of Normal inking level samples

Sample #	C	M	Y	K
1	0.90	0.88	0.82	1.07
2	0.91	0.89	0.83	1.05
3	0.91	0.89	0.82	1.08
4	0.90	0.89	0.81	1.06
5	0.90	0.89	0.82	1.07
6	0.90	0.90	0.82	1.06
7	0.90	0.89	0.81	1.08
8	0.90	0.89	0.81	1.07
9	0.91	0.89	0.82	1.06
10	0.90	0.89	0.82	1.05
11	0.90	0.89	0.81	1.06
12	0.90	0.89	0.81	1.07
13	0.89	0.90	0.81	1.05
14	0.90	0.89	0.82	1.06
15	0.90	0.89	0.81	1.05
16	0.90	0.89	0.83	1.06
17	0.90	0.89	0.81	1.08
18	0.90	0.91	0.80	1.06
19	0.91	0.90	0.82	1.06
20	0.91	0.90	0.81	1.05
Average	0.90	0.89	0.82	1.06
Target Density	0.93	0.93	0.88	1.08
Range	0.02	0.03	0.03	0.03

Table C2. Solid ink densities of Low1 inking level samples

Sample #	C	M	Y	K
1	0.83	0.82	0.74	0.95
2	0.83	0.82	0.73	0.96
3	0.82	0.83	0.73	0.96
4	0.83	0.82	0.73	0.96
5	0.82	0.83	0.74	0.95
6	0.83	0.82	0.73	0.95
7	0.83	0.82	0.73	0.94
8	0.83	0.83	0.75	0.95
9	0.82	0.82	0.74	0.98
10	0.83	0.82	0.75	0.96
11	0.83	0.82	0.74	0.94
12	0.82	0.83	0.74	0.94
13	0.83	0.83	0.75	0.98
14	0.82	0.82	0.75	0.96
15	0.84	0.82	0.75	0.96
16	0.83	0.82	0.76	0.95
17	0.84	0.82	0.74	0.96
18	0.84	0.83	0.76	0.95
19	0.85	0.83	0.73	0.97
20	0.85	0.83	0.73	0.95
Average	0.83	0.82	0.74	0.96
Target Density	0.83	0.83	0.78	0.98
Range	0.03	0.01	0.03	0.04

Table C3. Solid ink densities of Low2 inking level samples

Sample #	C	M	Y	K
1	0.71	0.71	0.66	0.87
2	0.71	0.71	0.66	0.88
3	0.71	0.72	0.65	0.85
4	0.70	0.72	0.66	0.86
5	0.70	0.71	0.68	0.87
6	0.72	0.71	0.66	0.89
7	0.72	0.71	0.66	0.87
8	0.71	0.71	0.66	0.86
9	0.70	0.72	0.67	0.88
10	0.71	0.72	0.66	0.87
11	0.70	0.71	0.66	0.86
12	0.72	0.72	0.69	0.87
13	0.72	0.72	0.66	0.86
14	0.71	0.72	0.65	0.87
15	0.71	0.71	0.68	0.87
16	0.72	0.71	0.67	0.86
17	0.71	0.71	0.66	0.85
18	0.71	0.71	0.66	0.87
19	0.70	0.71	0.69	0.87
20	0.70	0.70	0.67	0.88
Average	0.71	0.71	0.67	0.87
Target Density	0.73	0.73	0.68	0.88
Range	0.02	0.02	0.04	0.04

Table C4. Solid ink densities of High1 inking level samples

Sample #	C	M	Y	K
1	0.98	0.97	0.90	1.11
2	0.98	0.99	0.90	1.08
3	0.98	0.99	0.91	1.09
4	0.99	0.98	0.92	1.10
5	0.98	0.97	0.91	1.10
6	0.99	0.97	0.89	1.10
7	0.99	0.97	0.90	1.07
8	0.98	0.97	0.90	1.11
9	0.99	0.98	0.90	1.08
10	0.99	0.97	0.92	1.08
11	0.98	0.97	0.90	1.10
12	0.98	0.97	0.91	1.09
13	0.99	0.98	0.89	1.08
14	0.99	0.98	0.90	1.09
15	0.99	0.98	0.91	1.10
16	0.97	0.98	0.90	1.09
17	0.98	0.98	0.90	1.09
18	0.99	0.96	0.92	1.06
19	0.98	0.99	0.91	1.09
20	0.98	0.98	0.91	1.09
Average	0.98	0.98	0.91	1.09
Target Density	1.03	1.03	0.98	1.18
Range	0.02	0.03	0.03	0.05

Table C5. Solid ink densities of High2 inking level samples

Sample #	C	M	Y	K
1	1.07	1.04	0.97	1.16
2	1.07	1.05	0.95	1.16
3	1.08	1.05	0.96	1.16
4	1.09	1.04	0.97	1.17
5	1.07	1.05	0.98	1.15
6	1.06	1.06	0.97	1.16
7	1.08	1.05	0.96	1.17
8	1.08	1.05	0.97	1.17
9	1.06	1.05	0.96	1.17
10	1.07	1.03	0.97	1.18
11	1.08	1.04	0.96	1.16
12	1.07	1.03	0.97	1.17
13	1.07	1.04	0.97	1.18
14	1.07	1.04	0.97	1.17
15	1.07	1.05	0.97	1.18
16	1.08	1.06	0.98	1.18
17	1.08	1.06	0.96	1.16
18	1.06	1.05	0.95	1.15
19	1.07	1.05	0.96	1.16
20	1.07	1.04	0.96	1.16
Average	1.07	1.05	0.97	1.17
Target Density	1.13	1.13	1.08	1.28
Range	0.03	0.03	0.03	0.03

Appendix D

Appendix D

Table D1. Total border length (pixels) on film dot area of various FM and AM screens within a CCD captured image frame.

% FDA	21μm	32μm	42μm	53μm
0	0	0	0	0
10	19338	13138	9431	7246
20	35493	22331	16986	12971
30	38937	26584	19576	15632
40	47347	31668	22664	18412
50	44496	31216	22807	18150
60	39555	27938	21476	17675
70	32476	23614	17010	14278
80	22830	15418	13185	11094
90	11593	7578	6818	5535
100	0	0	0	0

% FDA	64μm	84μm	100-lpi	85-lpi
0	0	0	0	0
10	5678	4324	5393	4157
20	10025	7460	6937	5939
30	14088	9669	8790	7151
40	15798	12116	9574	8244
50	17010	11641	9550	8647
60	15656	11760	9099	7959
70	13042	8909	7697	6676
80	9503	7412	6248	5607
90	4941	3825	4371	3825
100	0	0	0	0

Appendix E

Appendix E

Table E1. Cyan tint densities at Normal inking level

% FDA	21µm	32µm	42µm	53µm	64µm	84µm	100-lpi	85-lpi
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.20	0.18	0.17	0.15	0.15	0.11	0.11	0.11
20	0.36	0.36	0.32	0.30	0.28	0.23	0.20	0.20
30	0.49	0.47	0.45	0.42	0.38	0.33	0.29	0.27
40	0.55	0.54	0.53	0.50	0.49	0.42	0.37	0.36
50	0.60	0.60	0.56	0.57	0.55	0.51	0.45	0.42
60	0.62	0.61	0.62	0.61	0.59	0.54	0.49	0.47
70	0.66	0.64	0.64	0.65	0.64	0.62	0.54	0.52
80	0.68	0.66	0.64	0.68	0.67	0.66	0.59	0.57
90	0.68	0.68	0.66	0.69	0.68	0.67	0.64	0.63
100	0.68	0.68	0.69	0.70	0.69	0.69	0.68	0.68

Table E2. Cyan Dot gain at Normal inking level

% FDA	21µm	32µm	42µm	53µm	64µm	84µm	100-lpi	85-lpi
0	0	0	0	0	0	0	0	0
10	37	38	31	26	27	18	18	18
20	51	51	46	42	40	32	27	27
30	56	54	51	47	43	37	32	29
40	51	51	49	45	45	38	32	31
50	45	45	41	41	40	37	32	28
60	36	35	36	34	33	29	26	24
70	29	27	27	27	27	26	20	18
80	20	19	17	19	19	18	14	12
90	10	10	8	9	9	9	7	7
100	0	0	0	0	0	0	0	0

Appendix F

Appendix F

Table F1. Border length ratio of various FM to 85-lpi AM screens

%FDA	21μm	32μm	42μm	53μm	64μm	84μm	100-lpi	85-lpi
0	1	1	1	1	1	1	1	1
10	4.65	3.16	2.27	1.74	1.37	1.04	1.30	1
20	5.98	3.76	2.86	2.18	1.69	1.26	1.17	1
30	5.45	3.72	2.74	2.19	1.97	1.35	1.23	1
40	5.74	3.84	2.75	2.23	1.92	1.47	1.16	1
50	5.15	3.61	2.64	2.10	1.96	1.35	1.10	1
60	4.97	3.51	2.70	2.22	1.96	1.46	1.14	1
70	4.86	3.54	2.55	2.14	1.95	1.33	1.15	1
80	4.07	2.75	2.35	1.98	1.69	1.32	1.11	1
90	3.03	1.98	1.78	1.45	1.29	1.00	1.14	1
100	1	1	1	1	1	1	1	1

Table F2. Dot gain difference between various FM and 85-lpi AM screens

%FDA	21μm	32μm	42μm	53μm	64μm	84μm	100-lpi	85-lpi
0	0	0	0	0	0	0	0	0
10	18.95	20.18	12.42	9.86	9.10	0.36	0.00	0
20	25.48	24.58	18.86	18.50	14.18	5.98	0.00	0
30	28.06	25.05	22.55	22.44	16.12	9.61	3.06	0
40	20.70	19.55	17.34	18.08	15.35	8.11	1.26	0
50	17.50	16.31	12.70	17.11	13.58	10.10	3.21	0
60	13.72	11.80	11.94	14.98	11.52	7.51	1.93	0
70	11.76	9.22	8.63	13.14	10.44	9.06	1.72	0
80	8.87	6.37	4.48	10.94	8.25	7.61	1.53	0
90	4.48	1.98	1.39	7.78	4.48	3.86	0.67	0
100	0	0	0	0	0	0	0	0

Appendix G

Appendix G

Following is the statistic analysis used to test the relationship between the maximum border length ratio and the maximum dot gain difference. Fisher's transformation was used to compare these two correlation coefficients.

Group 1 : Data derived from the maximum border length ratio

x_1 : The maximum border length ratio (FM / 85-lpi AM)

y_1 : The dot gain difference (FM – 85-lpi AM), where the maximum border length ratio occurs

Group 2 : Data derived from the maximum dot gain difference

x_2 : The border length ratio (FM / 85-lpi AM), where the maximum dot gain difference occurs

y_2 : The maximum dot gain difference (FM – 85-lpi AM)

The following tests were used.

Group 1

	21μm	32μm	42μm	53μm	64μm	84μm
x_1	5.98	3.84	2.86	2.23	1.97	1.47
y_1	25.48	19.55	18.86	18.08	16.12	8.11

$S_{x_1x_1} = 13.58$ $S_{x_1y_1} = 40.58$ $S_{y_1y_1} = 159.91$

$$r = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}} = 0.87$$

Group 2

	21μm	32μm	42μm	53μm	64μm	84μm
x_2	5.45	3.72	2.74	2.19	1.97	1.35
y_2	28.06	25.05	22.55	22.44	16.12	10.10

$S_{x_2x_2} = 10.97$ $\quad S_{x_2y_2} = 41.49$ $\quad S_{y_2y_2} = 212.876$

$$r = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}} = 0.86$$

Significance level $\alpha = 0.05$

H_o: $\rho 1 = \rho 2$ against H_a: $\rho 1 \neq \rho 2$

is tested with

$$z = \frac{Z_{r1} - Z_{r2}}{\sqrt{\frac{1}{n_1 - 3} + \frac{1}{n_1 - 3}}} = 0.049$$

Reject H_o if $|z| \geq z_{\alpha/2}$

Since $z_{\alpha/2} = 1.96$, there is no significant difference between the two correlation coefficients. The correlation between the dot gain difference for the maximum border length ratio may be the same as the border length ratio for the maximum dot gain difference. Therefore, we can conclude that the maximum border length ratio for a given screen is where the maximum dot gain difference occurs.

Appendix H

Appendix H

Table H1. The average CIE LAB data of 85-lpi AM screened IT8.7/3 target at Normal inking level (average of five samples)

Patch #	Average L *	Average a*	Average b *	Patch #	Average L *	Average a*	Average b *
A1	57.51	-23.85	-27.16	C1	59.80	-23.16	-24.88
A2	55.09	44.00	-0.75	C2	60.75	-21.96	-23.36
A3	78.11	-2.97	53.38	C3	62.00	-20.34	-21.75
A4	41.42	3.88	-23.67	C4	63.61	-18.90	-19.81
A5	52.85	-35.50	12.15	C5	64.76	-17.23	-17.61
A6	53.03	42.24	22.60	C6	67.57	-14.93	-14.44
A7	39.18	-3.34	-3.61	C7	70.23	-11.87	-10.59
A8	45.42	4.41	-21.94	C8	71.72	-10.34	-8.54
A9	57.26	-30.22	13.51	C9	73.13	-8.63	-6.57
A10	56.80	35.00	21.86	C10	74.83	-6.79	-4.32
A11	54.44	5.12	-16.71	C11	76.60	-4.82	-1.84
A12	63.89	23.75	19.40	C12	77.47	-3.41	0.53
A13	53.17	0.45	2.64	C13	79.56	-1.56	1.96
B1	64.44	-20.66	12.00	D1	55.48	43.42	-0.73
B2	65.24	4.04	-8.85	D2	56.80	41.47	-0.97
B3	71.92	-11.02	8.65	D3	58.85	37.84	-1.37
B4	71.11	12.65	13.68	D4	60.50	34.50	-1.25
B5	34.90	-6.33	-4.38	D5	62.71	30.59	-1.41
B6	35.35	14.30	2.07	D6	65.51	26.00	-1.24
B7	42.40	-0.51	16.85	D7	69.07	20.23	-0.35
B8	31.44	2.13	-6.26	D8	70.63	17.32	0.02
B9	35.93	-11.48	5.53	D9	72.50	14.47	0.58
B10	36.61	15.49	9.02	D10	74.00	11.54	1.49
B11	31.40	-0.21	0.02	D11	75.94	8.50	1.87
B12	38.14	1.81	4.91	D12	77.43	6.58	2.75
B13	81.06	0.88	4.33	D13	79.36	3.97	3.08

Table H1 (continued)

Patch #	Average L *	a *	b *	Patch #	Average L *	a *	b *
E1	78.04	-2.83	52.59	H1	43.66	9.33	-12.67
E2	78.13	-2.86	49.33	H2	52.98	22.51	-1.41
E3	78.39	-2.72	45.28	H3	52.68	21.46	5.67
E4	78.49	-2.68	41.07	H4	48.68	27.65	8.92
E5	78.68	-2.56	37.78	H5	51.65	21.06	12.28
E6	79.03	-2.23	32.55	H6	51.71	20.59	16.50
E7	79.18	-1.73	26.18	H7	63.65	-1.26	24.94
E8	79.06	-1.59	23.56	H8	53.95	-18.98	14.91
E9	79.69	-1.17	20.03	H9	53.83	-18.48	9.88
E10	80.23	-0.82	16.89	H10	51.35	-23.92	6.19
E11	80.35	-0.41	12.98	H11	55.11	-14.43	-9.01
E12	80.25	-0.21	11.35	H12	44.20	-1.26	-14.52
E13	80.98	0.39	7.77	H13	46.10	3.57	-12.09
F1	40.70	1.78	4.84	I1	42.58	7.76	-1.15
F2	44.15	1.64	4.64	I2	48.78	11.98	-0.50
F3	47.82	1.50	4.49	I3	59.21	11.71	1.07
F4	51.53	1.39	4.36	I4	42.14	6.13	0.62
F5	55.23	1.34	4.39	I5	58.43	10.05	9.66
F6	59.66	1.28	4.25	I6	44.64	0.40	4.04
F7	64.62	1.15	4.20	I7	53.26	-0.33	11.41
F8	67.05	1.11	4.26	I8	64.78	-0.32	14.08
F9	69.68	1.08	4.21	I9	65.01	1.17	4.11
F10	72.26	1.15	4.41	I10	42.37	-6.73	1.02
F11	75.04	1.07	4.13	I11	49.42	-9.07	3.90
F12	76.09	0.88	4.27	I12	59.50	-8.69	7.50
F13	78.86	1.13	4.24	I13	43.25	-5.12	-2.54
G1	47.28	20.48	-14.91	J1	55.12	4.30	-4.34
G2	45.59	17.73	-2.46	J2	40.95	1.66	-3.74
G3	54.25	42.62	12.22	J3	60.70	-5.81	-1.81
G4	45.01	16.77	6.13	J4	50.86	-6.46	-2.64
G5	63.48	22.44	33.87	J5	32.78	0.44	0.90
G6	53.16	-0.78	15.99	J6	33.76	0.22	0.69
G7	44.96	1.22	0.88	J7	35.14	-0.28	0.25
G8	64.40	-22.39	30.84	J8	34.43	-0.01	1.13
G9	46.90	-16.23	6.18	J9	34.54	-0.24	1.19
G10	56.01	-31.86	-0.06	J10	35.95	-1.08	0.92
G11	47.40	-13.55	-6.67	J11	38.03	-1.35	0.03
G12	49.25	-6.88	-24.86	J12	34.21	-0.05	2.00
G13	41.16	0.10	-10.08	J13	35.69	-0.24	1.97

Table H1 (continued)

Patch #	Average L*	a*	b*
K1	38.31	-0.76	1.36
K2	41.18	-1.27	1.33
K3	44.91	-1.87	0.66
K4	36.25	0.01	2.52
K5	38.45	-0.48	2.23
K6	42.02	-1.31	1.91
K7	45.90	-2.05	1.32
K8	51.02	-2.99	0.40
K9	53.59	-3.23	0.03
K10	37.92	0.38	3.63
K11	40.80	0.27	3.28
K12	45.85	0.06	2.96
K13	51.94	-0.43	2.51
L1	59.05	-1.26	1.84
L2	62.43	-1.74	1.57
L3	38.12	1.14	4.25
L4	41.99	0.83	3.89
L5	48.29	0.40	3.59
L6	54.69	-0.06	3.38
L7	63.93	-0.47	2.91
L8	67.59	-0.97	2.98
L9	40.02	-4.23	-1.94
L10	43.05	-4.62	-1.22
L11	48.91	-4.48	-0.56
L12	56.75	-4.24	-0.04
L13	67.12	-2.16	1.13
M1	73.60	-0.97	2.64
M2	76.58	-0.60	3.12
M3	50.78	-18.87	-20.01
M4	48.64	34.26	-0.35
M5	66.38	-2.66	42.39
M6	38.37	3.24	-18.15
M7	48.27	-28.52	12.60
M8	47.33	32.12	17.53
M9	48.86	4.55	-11.97
M10	56.38	-16.30	10.45
M11	56.04	17.40	16.20
M12	35.14	3.56	-13.13
M13	43.06	-22.20	9.59
N1	43.42	25.69	14.54
N2	43.85	3.71	-8.68
N3	50.46	-12.54	9.33
N4	49.87	14.43	13.28
N5	40.08	-9.65	-7.93
N6	39.23	19.58	1.19
N7	48.91	-1.29	24.03
N8	33.40	2.83	-8.98
N9	39.84	-16.18	8.44
N10	38.70	18.51	11.18
N11	38.27	2.64	-4.61
N12	42.22	-8.53	6.93
N13	42.89	10.20	10.45

Table H2. The average CIE LAB data of compensated 42μm FM screened IT8.7/3 target at Normal inking level (average of five samples)

	Average				Average		
Patch #	L*	a*	b*	Patch #	L*	a*	b*
A1	57.85	-23.79	-26.64	C1	59.74	-23.14	-24.75
A2	54.98	44.10	-0.68	C2	60.69	-22.88	-23.69
A3	78.05	-2.97	53.19	C3	62.95	-21.66	-21.29
A4	41.96	4.18	-23.50	C4	64.92	-20.07	-18.65
A5	53.24	-35.63	11.77	C5	67.67	-17.25	-14.97
A6	53.21	41.76	21.95	C6	69.73	-15.09	-12.29
A7	39.57	-2.19	-2.58	C7	70.95	-13.45	-10.34
A8	46.87	3.60	-22.14	C8	71.91	-12.37	-9.05
A9	58.19	-32.06	12.55	C9	73.45	-10.33	-6.66
A10	57.42	35.30	20.20	C10	75.30	-7.76	-4.27
A11	58.71	3.54	-15.60	C11	77.17	-5.00	-1.46
A12	66.70	20.46	16.11	C12	78.53	-3.31	0.42
A13	58.16	-0.29	1.86	C13	80.22	-0.77	2.93
B1	67.15	-20.62	11.06	D1	55.55	43.29	-1.00
B2	64.87	2.36	-10.84	D2	57.11	41.18	-1.73
B3	71.65	-13.88	8.06	D3	59.39	37.78	-2.61
B4	70.85	13.63	12.70	D4	61.59	33.97	-3.13
B5	34.81	-5.94	-3.85	D5	65.16	27.81	-3.05
B6	35.45	14.37	2.14	D6	67.65	23.79	-2.62
B7	42.33	-0.50	16.53	D7	69.08	21.16	-2.21
B8	31.72	2.36	-6.13	D8	70.43	18.81	-1.86
B9	35.90	-11.70	5.21	D9	72.09	15.93	-1.04
B10	36.23	15.25	8.93	D10	73.52	13.48	-0.20
B11	31.36	-0.52	0.49	D11	76.04	8.90	1.27
B12	38.35	1.81	4.94	D12	77.78	6.18	2.20
B13	81.12	0.74	4.34	D13	79.97	2.78	3.43

Table H2 (continued)

	Average					Average	
Patch #	L *	a *	b *	Patch #	L *	a *	b *
E1	77.92	-2.93	52.63	H1	43.49	8.64	-13.31
E2	78.30	-3.09	48.51	H2	53.44	19.54	-3.49
E3	78.59	-3.10	44.65	H3	53.37	18.97	1.23
E4	78.78	-3.06	40.22	H4	48.73	26.06	7.33
E5	79.21	-2.78	33.50	H5	52.40	18.37	9.97
E6	79.61	-2.40	28.88	H6	52.36	18.42	15.84
E7	79.69	-2.20	26.50	H7	63.42	-2.35	22.45
E8	79.83	-2.16	24.11	H8	54.46	-19.43	15.44
E9	79.99	-1.57	20.77	H9	55.30	-18.58	9.31
E10	80.25	-1.12	17.10	H10	52.11	-23.62	4.27
E11	80.73	-0.49	12.64	H11	56.85	-14.54	-9.05
E12	80.69	-0.25	10.22	H12	45.54	-2.83	-16.01
E13	81.01	0.43	6.42	H13	48.09	2.65	-12.76
F1	39.74	1.85	5.01	I1	42.29	6.66	-2.54
F2	42.98	1.81	5.05	I2	51.00	12.96	-2.76
F3	47.47	1.75	5.09	I3	61.12	6.71	0.22
F4	51.58	1.63	5.03	I4	42.55	6.01	1.17
F5	57.64	1.51	4.84	I5	60.28	5.45	5.91
F6	62.56	1.41	4.70	I6	46.02	-1.23	4.82
F7	64.54	1.38	4.55	I7	56.99	-1.72	13.00
F8	66.73	1.22	4.45	I8	64.68	-1.14	9.17
F9	69.51	1.18	4.41	I9	65.40	0.38	2.93
F10	71.78	1.12	4.41	I10	43.64	-7.68	1.40
F11	75.19	1.03	4.14	I11	52.24	-12.36	5.22
F12	77.01	0.92	4.31	I12	61.98	-6.51	5.51
F13	79.44	0.90	4.07	I13	45.15	-6.44	-3.50
G1	47.61	21.40	-14.02	J1	58.30	1.53	-3.06
G2	46.95	19.52	-4.40	J2	40.72	1.71	-5.62
G3	54.53	42.77	9.72	J3	61.95	-5.27	-1.30
G4	45.88	18.49	8.15	J4	53.88	-9.44	-4.52
G5	65.48	19.62	35.38	J5	32.96	0.16	0.69
G6	56.34	-2.51	19.87	J6	33.89	0.36	0.61
G7	46.19	-0.08	-0.72	J7	35.60	0.09	-0.19
G8	66.44	-22.09	34.50	J8	34.27	-0.38	1.03
G9	49.00	-19.62	7.96	J9	35.40	-0.54	0.73
G10	57.44	-31.11	-3.69	J10	37.34	-1.23	0.04
G11	50.47	-16.00	-9.57	J11	40.60	-1.86	-0.47
G12	51.77	-10.14	-25.65	J12	34.93	-0.50	1.68
G13	41.90	1.24	-13.62	J13	37.41	-0.93	1.67

Table H2 (continued)

Patch #	L *	Average a *	b *
K1	39.95	-2.30	0.61
K2	44.53	-3.89	-0.95
K3	47.33	-4.81	-1.33
K4	36.97	0.58	3.03
K5	38.84	0.08	2.92
K6	43.74	-0.39	2.64
K7	48.81	-1.01	1.89
K8	52.68	-1.80	1.80
K9	56.04	-2.14	0.91
K10	37.69	0.74	3.54
K11	40.89	0.51	3.47
K12	47.21	-0.21	3.14
K13	54.90	-1.19	2.14
L1	58.27	-3.08	1.13
L2	62.07	-3.74	-0.11
L3	38.15	0.95	4.09
L4	41.70	0.83	4.15
L5	47.94	0.33	3.73
L6	57.54	-0.55	2.94
L7	63.18	-0.93	2.38
L8	68.39	-1.51	1.99
L9	40.12	-4.02	-2.74
L10	44.48	-6.05	-2.83
L11	52.46	-7.45	-2.89
L12	59.84	-3.32	0.35
L13	67.88	-4.06	-0.04
M1	73.62	-2.55	1.00
M2	77.53	-1.13	2.65
M3	50.50	-18.31	-18.32
M4	48.46	32.61	-0.59
M5	65.15	-2.52	40.47
M6	38.82	3.65	-17.52
M7	47.28	-27.11	11.92
M8	46.87	31.01	17.03
M9	52.22	3.21	-10.30
M10	58.71	-14.53	9.61
M11	57.60	15.11	12.75
M12	36.92	3.68	-14.70
M13	45.04	-24.19	10.11

Patch #	L *	Average a *	b *
N1	44.02	26.84	14.95
N2	47.85	2.45	-8.06
N3	53.87	-12.30	8.08
N4	53.51	12.15	12.21
N5	39.84	-9.20	-6.82
N6	39.16	18.78	1.23
N7	48.35	-1.07	22.85
N8	33.74	3.25	-8.67
N9	40.07	-16.84	7.71
N10	39.27	18.73	11.30
N11	40.45	2.60	-2.78
N12	44.17	-6.74	6.63
N13	44.31	8.01	9.06

Table H3. The average CIE LAB data of 85-lpi AM screened IT8.7/3 target at Low1 inking level (average of five samples)

	Average				Average		
Patch #	L *	a *	b *	Patch #	L *	a *	b *
A1	59.32	-23.49	-25.57	C1	61.40	-22.32	-23.04
A2	56.84	41.54	-2.13	C2	62.38	-20.94	-21.55
A3	78.66	-3.39	47.24	C3	64.12	-19.15	-19.36
A4	44.37	3.53	-23.46	C4	65.46	-17.40	-17.41
A5	56.43	-34.16	9.70	C5	66.70	-15.85	-15.43
A6	55.12	39.33	19.82	C6	68.90	-13.54	-12.54
A7	42.18	-2.28	-4.87	C7	71.67	-10.47	-8.75
A8	48.58	4.53	-21.06	C8	72.89	-9.08	-7.13
A9	60.30	-28.06	11.38	C9	74.34	-7.47	-5.34
A10	59.18	32.09	19.71	C10	75.74	-5.91	-3.16
A11	57.47	4.82	-15.24	C11	77.22	-4.20	-1.23
A12	65.95	21.40	17.06	C12	78.20	-2.96	0.54
A13	56.25	0.44	1.68	C13	79.95	-1.17	2.29
B1	66.71	-18.99	10.80	D1	57.39	40.86	-1.87
B2	67.18	3.86	-7.88	D2	58.72	38.23	-2.10
B3	73.38	-9.85	8.11	D3	60.61	35.16	-1.92
B4	72.47	11.66	12.14	D4	62.31	31.93	-1.63
B5	38.13	-7.71	-4.97	D5	64.61	27.83	-1.64
B6	38.41	15.60	1.58	D6	67.23	23.66	-1.04
B7	45.66	-0.40	17.31	D7	70.43	18.41	-0.31
B8	33.84	2.45	-7.10	D8	71.86	15.85	0.30
B9	39.01	-12.08	5.75	D9	73.44	13.17	0.71
B10	39.02	15.68	9.06	D10	75.03	10.62	1.32
B11	33.66	0.18	-0.31	D11	76.70	7.90	2.14
B12	42.41	2.00	5.46	D12	77.95	6.13	2.59
B13	81.09	1.00	4.48	D13	79.72	3.74	3.26

Table H3 (continued)

Patch #	Average L*	a*	b*
E1	78.48	-3.15	46.50
E2	78.60	-2.95	44.03
E3	78.84	-2.80	40.12
E4	79.13	-2.67	36.79
E5	79.27	-2.47	33.32
E6	79.54	-2.04	29.25
E7	79.70	-1.59	23.45
E8	79.83	-1.34	21.28
E9	80.01	-0.93	18.38
E10	80.22	-0.54	15.41
E11	80.71	-0.05	12.27
E12	80.55	0.06	10.30
E13	81.17	0.55	7.20
F1	45.19	1.96	5.23
F2	48.30	1.80	4.98
F3	52.00	1.61	4.69
F4	54.99	1.53	4.57
F5	58.31	1.44	4.47
F6	62.34	1.38	4.39
F7	66.79	1.37	4.32
F8	68.96	1.22	4.22
F9	71.17	1.19	4.20
F10	73.31	1.22	4.27
F11	75.88	1.20	4.12
F12	76.87	1.16	4.31
F13	79.40	1.22	4.26
G1	49.62	20.23	-14.76
G2	48.63	17.54	-3.40
G3	56.05	40.31	9.66
G4	47.96	16.45	4.30
G5	65.68	19.62	29.98
G6	56.19	-0.70	13.77
G7	48.04	1.64	0.08
G8	66.46	-20.70	27.53
G9	50.05	-15.39	5.15
G10	58.97	-29.66	0.08
G11	50.65	-12.45	-6.61
G12	52.13	-6.91	-23.28
G13	44.02	1.17	-10.45

Patch #	Average L*	a*	b*
H1	46.49	9.47	-13.02
H2	55.63	21.10	-2.02
H3	55.38	20.09	4.22
H4	51.41	26.49	6.41
H5	54.72	19.37	9.97
H6	54.72	18.86	14.25
H7	65.95	-1.43	21.15
H8	57.31	-17.61	13.26
H9	56.79	-16.88	8.40
H10	54.39	-22.41	4.68
H11	58.27	-13.34	-8.22
H12	47.48	-0.97	-14.03
H13	49.31	3.79	-11.80
I1	45.69	8.01	-2.75
I2	52.05	12.04	-1.18
I3	61.73	11.06	0.66
I4	45.56	7.09	-1.09
I5	61.26	9.50	8.20
I6	48.33	0.75	2.62
I7	56.53	0.05	9.96
I8	66.99	-0.21	12.34
I9	67.41	1.28	3.92
I10	46.07	-5.64	0.49
I11	53.06	-8.41	3.26
I12	62.25	-7.90	6.34
I13	46.85	-4.08	-3.11
J1	57.87	4.37	-4.19
J2	43.65	2.20	-5.29
J3	63.10	-5.15	-2.10
J4	54.10	-5.67	-3.10
J5	36.10	0.79	0.03
J6	37.04	0.74	-0.22
J7	38.39	0.56	-0.68
J8	37.40	0.43	0.94
J9	38.02	0.26	0.82
J10	39.78	-0.63	0.33
J11	41.85	-0.93	-0.13
J12	37.83	0.21	1.97
J13	39.82	-0.06	1.87

Table H3 (continued)

Patch #	L*	Average a*	b*
K1	42.51	-1.17	1.27
K2	45.00	-1.65	0.90
K3	48.76	-2.48	0.08
K4	40.67	-0.07	2.55
K5	43.29	-0.69	2.24
K6	46.60	-1.68	2.14
K7	50.24	-2.38	1.62
K8	54.89	-3.14	1.11
K9	57.11	-3.40	0.54
K10	42.90	0.39	3.98
K11	46.15	0.07	3.58
K12	51.02	-0.32	3.35
K13	56.39	-0.78	2.78
L1	62.09	-1.47	2.09
L2	65.14	-1.87	1.93
L3	43.59	1.09	4.61
L4	47.35	0.80	4.34
L5	53.09	0.24	3.98
L6	58.98	-0.12	3.67
L7	66.53	-0.63	3.13
L8	70.08	-0.92	3.19
L9	43.12	-4.31	-2.27
L10	46.21	-4.95	-1.07
L11	52.26	-5.09	-0.68
L12	59.94	-4.57	0.28
L13	69.08	-2.42	1.30
M1	74.77	-0.96	2.80
M2	77.25	-0.60	3.18
M3	54.01	-19.21	-19.08
M4	52.05	33.00	-1.71
M5	69.11	-2.98	39.50
M6	42.15	2.42	-18.92
M7	51.85	-27.87	11.83
M8	50.45	30.48	16.52
M9	52.67	3.58	-11.21
M10	59.59	-15.69	9.99
M11	59.45	15.69	15.45
M12	38.83	3.22	-14.57
M13	47.15	-22.77	9.41

Patch #	L*	Average a*	b*
N1	47.08	25.50	14.13
N2	48.29	3.20	-8.55
N3	54.61	-12.38	9.12
N4	54.08	13.76	13.18
N5	44.48	-10.87	-8.32
N6	43.15	20.62	0.30
N7	53.37	-1.38	24.56
N8	37.53	2.96	-10.37
N9	43.88	-17.16	8.61
N10	42.93	19.20	12.13
N11	43.04	2.16	-5.11
N12	47.18	-9.10	7.31
N13	47.72	10.46	11.05

Table H4. The average CIE LAB data of compensated 42μm FM screened IT8.7/3 target at Low1 inking level (average of five samples)

	Average					Average		
Patch #	L *	a *	b *		Patch #	L *	a *	b *
A1	59.86	-23.33	-24.68		C1	61.59	-22.49	-22.63
A2	56.85	41.57	-2.17		C2	62.64	-21.70	-21.54
A3	78.69	-3.36	47.29		C3	64.61	-20.11	-19.03
A4	44.64	3.84	-23.29		C4	66.74	-18.23	-16.41
A5	56.11	-34.48	10.34		C5	69.36	-15.25	-12.78
A6	55.36	39.20	19.42		C6	71.25	-13.15	-10.15
A7	42.27	-1.62	-3.81		C7	72.58	-11.56	-8.55
A8	49.86	3.25	-21.62		C8	73.17	-10.80	-7.28
A9	61.26	-29.28	11.23		C9	74.47	-8.89	-5.35
A10	59.48	32.46	17.87		C10	76.10	-6.46	-3.10
A11	61.55	3.07	-14.01		C11	77.76	-4.21	-0.63
A12	68.51	18.15	14.00		C12	78.92	-2.83	0.80
A13	61.01	-0.62	1.59		C13	80.44	-0.48	3.12
B1	69.23	-18.51	9.91		D1	57.47	40.63	-2.01
B2	66.99	2.59	-9.61		D2	58.95	38.73	-2.67
B3	73.57	-11.92	7.58		D3	61.20	34.92	-3.32
B4	72.43	11.96	11.53		D4	63.48	31.26	-3.37
B5	38.51	-7.44	-4.50		D5	66.96	24.86	-3.06
B6	38.64	15.79	1.47		D6	69.29	21.17	-2.35
B7	46.06	-0.40	17.62		D7	70.72	18.80	-1.89
B8	34.39	2.45	-7.54		D8	71.73	16.69	-1.35
B9	39.34	-12.97	5.41		D9	73.29	14.18	-0.59
B10	39.12	16.34	9.37		D10	74.61	11.92	0.21
B11	33.74	-0.05	-0.03		D11	76.96	7.93	1.52
B12	43.09	2.02	5.41		D12	78.35	5.48	2.37
B13	81.11	0.93	4.38		D13	80.18	2.59	3.54

Table H4 (continued)

Patch #	L *	Average a *	b *
E1	78.30	-3.14	47.48
E2	78.83	-3.11	43.90
E3	78.92	-3.03	39.98
E4	79.30	-2.91	36.17
E5	79.63	-2.50	29.73
E6	79.96	-2.06	25.48
E7	80.05	-1.80	23.10
E8	80.23	-1.72	21.36
E9	80.37	-1.21	18.20
E10	80.42	-0.72	15.13
E11	80.87	-0.15	11.36
E12	80.86	0.06	9.28
E13	81.12	0.67	6.06
F1	44.73	2.00	5.38
F2	48.32	1.91	5.34
F3	52.21	1.80	5.14
F4	56.12	1.69	5.08
F5	61.89	1.48	4.80
F6	65.62	1.44	4.72
F7	67.42	1.44	4.57
F8	69.19	1.29	4.48
F9	71.67	1.25	4.44
F10	73.63	1.24	4.36
F11	76.34	1.20	4.14
F12	77.78	1.05	4.13
F13	80.05	1.09	4.13
G1	49.95	21.08	-13.82
G2	49.66	19.92	-4.50
G3	56.36	40.22	7.56
G4	48.84	18.44	6.91
G5	67.36	17.07	31.73
G6	59.18	-2.20	18.12
G7	49.19	0.93	-0.79
G8	68.53	-20.11	30.93
G9	52.32	-18.29	6.55
G10	60.02	-29.19	-3.77
G11	53.27	-14.89	-9.05
G12	54.39	-10.20	-24.23
G13	44.29	2.46	-12.68

Patch #	L *	Average a *	b *
H1	46.04	8.77	-13.09
H2	56.08	18.64	-3.73
H3	55.82	18.16	0.63
H4	51.57	24.66	5.99
H5	55.17	16.89	9.25
H6	55.15	17.28	13.73
H7	65.77	-2.15	20.05
H8	57.66	-18.27	13.60
H9	58.25	-17.21	8.08
H10	54.99	-22.40	3.79
H11	59.66	-13.38	-8.26
H12	48.46	-1.80	-15.03
H13	50.90	3.05	-12.15
I1	45.31	7.07	-2.74
I2	54.06	12.79	-2.83
I3	63.72	6.48	0.26
I4	46.10	6.45	0.32
I5	62.95	5.04	5.40
I6	49.12	-0.50	4.25
I7	60.11	-1.41	11.92
I8	67.15	-0.85	8.26
I9	67.80	0.57	2.57
I10	46.74	-6.49	0.48
I11	55.64	-11.28	4.69
I12	64.42	-6.22	4.90
I13	48.32	-4.86	-3.46
J1	60.88	1.65	-2.70
J2	44.06	2.36	-6.14
J3	64.80	-4.10	-0.91
J4	56.96	-8.61	-4.30
J5	36.16	0.52	0.24
J6	37.31	0.40	-0.13
J7	38.96	0.41	-0.66
J8	37.81	-0.29	0.71
J9	39.27	-0.22	0.36
J10	41.20	-0.71	-0.17
J11	44.61	-1.06	-0.68
J12	38.91	-0.82	1.71
J13	42.04	-0.96	1.82

Table H4 (continued)

Patch #	L*	Average a*	b*
K1	44.66	-2.78	0.47
K2	48.90	-4.02	-0.92
K3	51.21	-4.81	-1.48
K4	41.77	0.51	3.43
K5	43.98	-0.14	3.10
K6	48.64	-0.56	2.77
K7	53.18	-0.95	1.88
K8	56.66	-1.75	1.59
K9	59.43	-2.17	0.99
K10	42.92	0.73	3.97
K11	46.81	0.24	3.67
K12	53.26	-0.67	3.22
K13	59.89	-1.35	2.32
L1	61.76	-3.01	1.33
L2	65.08	-3.37	0.28
L3	43.31	0.94	4.51
L4	47.78	0.70	4.29
L5	53.65	0.18	3.81
L6	62.14	-0.53	3.24
L7	66.54	-0.81	2.51
L8	70.78	-1.27	2.50
L9	43.30	-4.23	-2.66
L10	47.58	-6.09	-2.46
L11	55.47	-7.41	-2.36
L12	62.42	-3.91	0.89
L13	69.86	-3.89	0.67
M1	74.68	-2.37	1.37
M2	78.31	-0.87	2.76
M3	54.10	-18.95	-18.01
M4	52.10	31.81	-1.90
M5	68.17	-2.78	39.08
M6	42.03	2.96	-18.38
M7	51.22	-27.59	10.84
M8	50.49	29.84	16.86
M9	55.92	2.79	-9.80
M10	62.21	-13.47	9.30
M11	61.28	13.91	12.10
M12	40.43	3.41	-15.94
M13	48.93	-24.98	9.85

Patch #	L*	Average a*	b*
N1	47.76	26.59	15.46
N2	52.72	2.18	-8.33
N3	58.44	-12.24	8.10
N4	58.09	11.54	12.19
N5	45.12	-10.79	-7.53
N6	43.89	20.52	0.28
N7	53.64	-1.22	24.61
N8	38.02	3.27	-10.40
N9	45.00	-18.08	8.56
N10	43.54	19.66	11.93
N11	45.69	2.37	-3.50
N12	49.65	-7.60	6.93
N13	50.02	8.10	9.70

Table H5. The average CIE LAB data of 85-lpi AM screened IT8.7/3 target at Low2 inking level (average of five samples)

Patch #	Average L*	Average a*	Average b*	Patch #	Average L*	Average a*	Average b*
A1	63.63	-21.84	-20.78	C1	65.66	-20.15	-18.21
A2	60.86	35.84	-3.76	C2	66.47	-18.87	-16.95
A3	79.26	-3.79	43.96	C3	67.60	-17.39	-15.34
A4	49.75	2.96	-22.03	C4	68.68	-15.74	-13.77
A5	60.48	-31.51	12.75	C5	69.48	-14.46	-12.19
A6	58.88	33.37	20.35	C6	71.42	-12.28	-9.81
A7	47.33	-3.28	-1.62	C7	73.51	-9.55	-6.76
A8	54.11	2.86	-19.19	C8	74.42	-8.35	-5.45
A9	63.79	-25.95	13.35	C9	75.67	-6.79	-3.88
A10	62.71	26.27	19.86	C10	76.83	-5.32	-2.15
A11	61.78	3.08	-13.29	C11	77.99	-3.72	-0.24
A12	68.85	17.11	16.85	C12	78.76	-2.62	1.30
A13	60.46	-1.08	3.64	C13	80.22	-1.00	2.45
B1	69.82	-17.18	11.91	D1	60.87	35.91	-3.46
B2	69.82	2.79	-6.47	D2	62.25	33.53	-3.24
B3	75.10	-9.12	8.51	D3	64.06	30.09	-2.84
B4	74.23	9.65	11.79	D4	65.57	27.39	-2.47
B5	42.32	-7.34	-3.47	D5	67.30	24.02	-2.12
B6	41.90	14.55	1.37	D6	69.74	20.02	-1.19
B7	49.19	-0.50	18.28	D7	72.41	15.58	-0.09
B8	37.87	2.23	-6.64	D8	73.64	13.25	0.39
B9	42.91	-11.91	7.41	D9	74.95	10.97	0.91
B10	42.39	14.11	10.35	D10	76.20	8.72	1.75
B11	37.33	-0.22	1.25	D11	77.67	6.64	2.33
B12	46.27	1.97	5.72	D12	78.70	5.04	2.84
B13	81.35	0.83	4.45	D13	80.11	3.05	3.50

Table H5 (continued)

	Average				Average		
Patch #	L *	a *	b *	Patch #	L *	a *	b *
E1	79.04	-3.29	42.63	H1	52.79	9.48	-10.79
E2	79.24	-3.11	39.88	H2	60.62	17.76	-1.60
E3	79.26	-2.90	36.91	H3	60.40	16.63	4.13
E4	79.48	-2.63	33.24	H4	56.62	22.62	6.64
E5	79.70	-2.45	30.63	H5	59.71	15.94	10.21
E6	80.00	-2.10	26.77	H6	59.59	15.15	14.42
E7	80.11	-1.66	21.69	H7	69.42	-1.97	19.92
E8	80.08	-1.35	19.70	H8	62.32	-15.65	14.34
E9	80.36	-0.97	17.26	H9	62.34	-14.85	10.24
E10	80.44	-0.69	14.55	H10	60.06	-19.71	7.30
E11	80.87	-0.22	11.61	H11	63.22	-11.65	-4.97
E12	80.75	-0.13	10.04	H12	54.07	-0.68	-10.95
E13	81.22	0.47	7.09	H13	55.56	3.39	-9.23
F1	48.65	1.97	5.53	I1	52.24	8.25	-0.47
F2	51.62	1.80	5.23	I2	57.99	10.38	-0.15
F3	54.94	1.64	4.96	I3	65.87	8.92	1.20
F4	57.97	1.55	4.84	I4	51.92	7.15	1.86
F5	61.21	1.43	4.61	I5	65.39	7.64	8.19
F6	64.84	1.35	4.55	I6	54.57	0.72	5.65
F7	68.77	1.31	4.46	I7	61.96	-0.25	11.02
F8	70.62	1.17	4.36	I8	70.36	-0.48	11.81
F9	72.64	1.12	4.29	I9	70.68	0.79	4.54
F10	74.54	1.09	4.46	I10	52.84	-5.08	3.43
F11	76.63	1.08	4.25	I11	58.90	-7.08	5.78
F12	77.61	1.00	4.33	I12	66.88	-6.59	7.95
F13	79.63	1.05	4.19	I13	53.50	-3.28	-0.27
G1	55.06	18.20	-13.72	J1	63.29	4.06	-2.31
G2	53.76	15.48	-2.63	J2	50.52	3.75	-2.59
G3	60.14	34.11	7.98	J3	67.55	-4.25	-0.13
G4	53.37	14.65	5.48	J4	60.05	-4.59	-0.70
G5	68.56	15.60	27.65	J5	41.90	1.36	1.59
G6	60.68	-1.74	14.69	J6	43.16	1.34	1.81
G7	53.79	0.93	1.84	J7	44.73	0.90	1.19
G8	69.61	-18.42	26.49	J8	43.20	0.60	2.41
G9	55.67	-14.32	7.61	J9	44.12	0.41	2.37
G10	63.52	-26.11	2.86	J10	46.39	-0.43	2.38
G11	56.45	-12.00	-3.84	J11	48.31	-0.43	1.94
G12	57.76	-6.73	-19.65	J12	43.53	0.57	3.49
G13	49.87	1.34	-8.23	J13	45.91	0.23	3.46

Table H5 (continued)

Patch #	Average L*	a*	b*
K1	48.75	-0.39	2.78
K2	51.49	-0.88	2.44
K3	54.76	-1.50	2.02
K4	46.83	0.25	3.52
K5	49.53	-0.47	3.24
K6	52.75	-1.26	3.20
K7	56.06	-1.93	2.99
K8	60.26	-2.55	2.57
K9	62.11	-2.72	2.35
K10	49.80	0.39	4.80
K11	52.69	0.17	4.43
K12	56.66	-0.11	4.23
K13	61.31	-0.53	3.59
L1	66.06	-1.14	3.12
L2	68.62	-1.50	2.69
L3	50.05	1.08	5.16
L4	53.75	0.78	4.68
L5	58.95	0.32	4.37
L6	63.67	-0.12	4.23
L7	69.76	-0.44	3.79
L8	72.61	-0.88	3.59
L9	49.42	-3.35	0.43
L10	52.51	-4.27	1.43
L11	57.79	-4.44	2.11
L12	64.40	-3.81	2.51
L13	71.84	-2.07	2.82
M1	76.31	-0.75	3.44
M2	78.36	-0.49	3.49
M3	60.13	-17.49	-14.78
M4	56.79	29.43	-2.82
M5	71.75	-3.12	36.69
M6	48.40	3.38	-17.27
M7	58.05	-25.33	14.60
M8	55.31	26.86	16.70
M9	58.20	3.28	-9.56
M10	64.47	-14.06	11.83
M11	63.52	13.35	15.06
M12	44.89	4.31	-13.86
M13	53.56	-21.40	13.02

Patch #	Average L*	a*	b*
N1	52.24	22.59	15.06
N2	54.13	3.47	-7.39
N3	60.08	-11.19	10.50
N4	58.89	12.17	13.03
N5	51.14	-10.27	-6.27
N6	48.70	19.61	-0.48
N7	58.49	-1.52	25.35
N8	43.44	3.49	-9.80
N9	50.20	-16.08	11.99
N10	48.28	17.91	13.44
N11	49.39	2.36	-4.29
N12	53.13	-8.44	9.28
N13	52.88	9.36	11.68

Table H6. The average CIE LAB data of compensated 42μm FM screened IT8.7/3 target at Low2 inking level (average of five samples)

Patch #	Average L *	a *	b *	Patch #	Average L *	a *	b *
A1	63.84	-21.70	-20.53	C1	65.54	-20.32	-18.43
A2	60.57	36.30	-3.66	C2	66.83	-19.25	-16.89
A3	79.21	-3.79	43.67	C3	68.59	-17.28	-14.31
A4	50.11	3.37	-21.59	C4	69.89	-15.73	-12.31
A5	60.47	-31.65	13.04	C5	71.96	-12.87	-9.01
A6	59.11	33.24	19.70	C6	73.53	-11.04	-7.18
A7	47.77	-2.05	-0.50	C7	74.50	-9.66	-5.69
A8	55.55	2.59	-18.86	C8	75.10	-8.89	-4.92
A9	65.22	-26.12	13.13	C9	75.87	-7.56	-3.66
A10	63.73	25.35	18.49	C10	77.42	-5.41	-1.49
A11	65.90	1.75	-11.43	C11	78.64	-3.49	0.45
A12	71.68	13.12	14.40	C12	79.41	-2.40	1.53
A13	65.36	-2.04	3.75	C13	80.69	-0.42	3.33
B1	71.93	-15.83	11.10	D1	60.89	35.70	-3.56
B2	70.35	1.37	-7.20	D2	62.57	33.04	-3.78
B3	75.27	-10.20	8.29	D3	64.86	29.30	-3.69
B4	74.73	8.93	11.41	D4	67.00	25.64	-3.44
B5	42.39	-6.87	-2.98	D5	70.00	20.12	-2.62
B6	41.59	14.42	1.43	D6	71.84	16.89	-1.65
B7	48.29	-0.38	17.56	D7	73.16	14.81	-1.07
B8	38.09	2.62	-6.42	D8	74.11	12.91	-0.59
B9	43.00	-11.59	7.47	D9	75.21	10.98	0.21
B10	42.05	13.96	10.07	D10	76.20	9.20	0.88
B11	37.38	0.09	1.82	D11	77.97	6.31	2.05
B12	46.13	1.95	5.65	D12	79.23	4.20	2.87
B13	81.36	0.71	4.42	D13	80.50	2.12	3.85

Table H6 (continued)

Patch #	Average L*	Average a*	Average b*	Patch #	Average L*	Average a*	Average b*
E1	78.91	-3.38	43.74	H1	52.51	9.37	-10.72
E2	79.30	-3.34	40.18	H2	61.63	15.28	-2.14
E3	79.45	-3.14	36.14	H3	61.59	14.76	1.93
E4	79.67	-2.93	32.35	H4	56.70	21.70	6.62
E5	79.91	-2.43	26.69	H5	60.78	13.36	9.98
E6	80.29	-2.00	23.18	H6	60.66	13.14	14.74
E7	80.17	-1.69	20.78	H7	69.93	-2.40	19.60
E8	80.45	-1.56	19.49	H8	63.52	-15.24	16.36
E9	80.54	-1.24	16.50	H9	64.07	-14.11	10.44
E10	80.59	-0.68	14.08	H10	61.09	-19.08	6.51
E11	80.97	-0.25	10.55	H11	65.20	-10.96	-4.55
E12	81.00	-0.01	8.87	H12	55.22	-1.38	-11.86
E13	81.16	0.56	5.95	H13	58.01	2.96	-8.71
F1	48.29	1.97	5.63	I1	51.68	8.51	-0.34
F2	52.11	1.85	5.49	I2	60.17	11.10	-0.70
F3	55.80	1.69	5.27	I3	68.27	4.83	1.80
F4	59.44	1.64	5.17	I4	52.39	7.83	3.05
F5	64.42	1.42	4.99	I5	67.80	3.77	6.46
F6	67.91	1.35	4.73	I6	56.09	0.38	7.01
F7	69.24	1.38	4.74	I7	65.49	-1.16	13.05
F8	70.91	1.22	4.58	I8	71.14	-0.92	8.93
F9	73.06	1.16	4.65	I9	71.63	0.21	3.88
F10	74.47	1.12	4.44	I10	53.70	-4.94	4.14
F11	76.80	1.06	4.30	I11	62.13	-8.70	7.50
F12	78.21	0.90	4.22	I12	69.21	-5.08	6.46
F13	80.12	0.96	4.24	I13	55.21	-4.24	0.03
G1	55.28	19.52	-12.96	J1	66.39	1.66	-0.01
G2	54.89	18.16	-3.35	J2	50.57	4.44	-3.22
G3	60.24	34.20	5.97	J3	69.49	-3.05	1.48
G4	54.22	16.39	8.30	J4	63.26	-6.55	-1.03
G5	70.62	12.00	29.81	J5	41.73	1.48	2.07
G6	64.09	-2.93	19.39	J6	43.36	1.76	2.03
G7	55.46	0.84	2.07	J7	45.35	1.53	1.81
G8	71.50	-17.13	29.68	J8	43.36	0.52	2.74
G9	58.07	-16.31	9.61	J9	45.64	0.44	2.58
G10	64.78	-25.27	-0.69	J10	47.91	-0.01	2.18
G11	58.98	-13.21	-5.66	J11	51.37	-0.24	2.14
G12	60.13	-9.61	-19.77	J12	44.64	-0.27	3.68
G13	50.75	2.88	-10.42	J13	48.41	-0.49	3.69

Table H6 (continued)

Patch #	L *	Average a *	b *
K1	51.60	-2.02	2.80
K2	55.58	-2.92	1.75
K3	57.75	-3.53	1.63
K4	47.92	0.71	4.78
K5	50.36	0.17	4.47
K6	55.06	-0.15	4.13
K7	59.37	-0.36	3.69
K8	62.33	-0.98	3.54
K9	64.65	-1.52	3.00
K10	49.14	0.83	4.84
K11	53.09	0.45	4.62
K12	58.95	-0.43	4.10
K13	64.95	-1.07	3.53
L1	66.37	-2.33	2.93
L2	69.15	-2.64	2.20
L3	50.06	0.96	5.11
L4	54.16	0.70	4.91
L5	59.82	0.21	4.23
L6	66.87	-0.40	3.81
L7	70.26	-0.51	3.32
L8	73.55	-0.93	3.28
L9	49.72	-2.36	0.62
L10	54.02	-4.10	1.21
L11	61.19	-5.51	0.79
L12	66.93	-3.18	3.24
L13	72.94	-3.08	2.47
M1	76.45	-1.96	2.57
M2	79.08	-0.65	3.42
M3	60.65	-17.02	-13.75
M4	56.89	28.34	-2.92
M5	71.28	-2.99	36.48
M6	48.65	4.04	-16.59
M7	57.33	-24.99	14.02
M8	55.36	26.30	17.20
M9	61.26	2.70	-7.72
M10	66.87	-11.31	10.55
M11	65.45	11.17	12.01
M12	46.90	4.36	-14.54
M13	55.60	-22.64	13.25

Patch #	L *	Average a *	b *
N1	52.83	24.06	15.91
N2	58.29	2.13	-6.57
N3	63.64	-10.12	9.62
N4	62.68	9.50	12.35
N5	52.15	-9.93	-5.38
N6	49.48	19.55	-0.49
N7	58.38	-1.34	24.88
N8	44.23	4.81	-9.44
N9	51.51	-16.18	12.02
N10	48.77	18.04	13.24
N11	52.09	2.61	-2.40
N12	55.64	-6.64	8.46
N13	55.72	6.84	10.36

Table H7. The average CIE LAB data of 85-lpi AM screened IT8.7/3 target at High1 inking level (average of five samples)

	Average					Average		
Patch #	L *	a *	b *		Patch #	L *	a *	b *
A1	54.10	-23.46	-29.81		C1	56.30	-23.16	-28.12
A2	52.43	46.64	1.38		C2	57.94	-22.10	-25.86
A3	77.06	-1.39	59.92		C3	59.29	-20.39	-24.01
A4	38.64	3.41	-24.27		C4	61.15	-18.95	-21.55
A5	49.29	-36.59	14.62		C5	63.03	-17.30	-19.18
A6	50.37	44.95	25.05		C6	65.85	-15.11	-15.88
A7	35.67	-4.04	-1.34		C7	69.13	-11.91	-11.52
A8	41.58	6.68	-22.11		C8	70.57	-10.48	-9.59
A9	54.03	-31.15	17.16		C9	72.33	-8.65	-7.26
A10	52.98	40.31	24.81		C10	74.11	-6.70	-4.81
A11	50.90	8.25	-17.05		C11	75.92	-4.79	-2.08
A12	60.52	28.89	22.39		C12	77.14	-3.57	-0.21
A13	49.34	3.26	4.10		C13	79.30	-1.35	1.68
B1	62.19	-21.67	15.60		D1	52.39	46.99	1.86
B2	62.70	6.32	-9.83		D2	53.48	45.84	1.12
B3	70.65	-11.50	11.10		D3	55.07	43.36	0.41
B4	68.45	16.28	15.55		D4	56.50	40.32	0.18
B5	32.51	-5.55	-4.70		D5	59.35	35.73	-0.67
B6	33.51	14.48	2.53		D6	62.53	30.79	-0.81
B7	41.24	-0.56	18.28		D7	66.74	24.30	-0.38
B8	29.41	2.08	-5.88		D8	68.72	20.77	-0.15
B9	33.85	-11.71	6.07		D9	70.56	17.96	0.23
B10	34.82	15.90	9.32		D10	72.60	14.38	1.08
B11	29.63	-0.67	0.70		D11	74.58	10.97	1.60
B12	36.58	1.84	4.68		D12	76.16	9.09	2.04
B13	80.65	1.58	4.45		D13	78.75	5.64	2.74

Table H7 (continued)

Patch #	Average L*	a*	b*	Patch #	Average L*	a*	b*
E1	76.90	-1.11	58.74	H1	39.81	9.26	-12.20
E2	76.79	-0.95	56.03	H2	49.53	25.85	-0.66
E3	77.31	-1.30	52.25	H3	49.02	24.31	6.02
E4	77.60	-1.43	48.72	H4	45.50	29.25	10.96
E5	77.86	-1.34	43.16	H5	48.07	24.03	13.62
E6	78.22	-1.06	37.59	H6	48.28	23.33	17.20
E7	78.67	-0.79	30.02	H7	60.98	-0.23	27.64
E8	78.84	-0.70	26.78	H8	49.70	-19.40	15.23
E9	79.10	-0.16	23.15	H9	49.76	-18.63	10.98
E10	79.49	-0.01	19.02	H10	46.61	-24.68	6.74
E11	79.98	0.54	14.60	H11	52.14	-14.11	-9.84
E12	79.68	0.62	12.99	H12	39.59	-0.91	-15.08
E13	80.71	1.11	8.42	H13	42.10	4.58	-12.50
F1	39.26	1.95	4.66	I1	38.99	6.51	-0.12
F2	42.55	1.85	4.51	I2	45.24	14.82	0.08
F3	46.43	1.70	4.39	I3	56.00	14.64	1.44
F4	49.82	1.72	4.25	I4	38.74	6.03	1.82
F5	53.68	1.66	4.21	I5	55.37	12.90	10.67
F6	58.42	1.71	4.23	I6	40.07	1.16	4.18
F7	63.62	1.85	4.09	I7	49.48	1.88	12.73
F8	66.12	1.80	4.13	I8	62.30	1.06	15.50
F9	68.74	1.83	4.05	I9	62.77	2.82	4.68
F10	71.56	1.93	4.04	I10	38.11	-6.13	0.28
F11	74.45	1.99	3.98	I11	45.45	-8.03	5.32
F12	75.56	1.66	4.33	I12	56.11	-7.66	8.13
F13	78.41	1.91	4.10	I13	38.91	-5.18	-2.53
G1	43.50	21.95	-13.97	J1	51.08	6.67	-4.54
G2	42.59	19.13	-1.28	J2	37.29	0.36	-3.03
G3	51.52	45.72	14.89	J3	57.61	-4.65	-2.30
G4	41.53	17.86	7.46	J4	46.66	-5.54	-2.64
G5	60.55	27.06	36.40	J5	30.58	-0.15	1.01
G6	49.04	1.05	16.74	J6	31.10	-0.36	0.81
G7	40.67	2.15	1.23	J7	32.10	-0.64	0.32
G8	61.49	-22.92	33.55	J8	31.73	-0.06	1.16
G9	41.95	-15.72	6.11	J9	31.97	0.06	1.29
G10	51.80	-32.73	0.22	J10	33.64	-0.79	0.73
G11	43.06	-12.94	-6.43	J11	34.94	-0.49	0.31
G12	44.95	-5.71	-26.44	J12	32.30	0.38	1.76
G13	37.11	-0.15	-9.35	J13	33.24	0.13	1.95

Table H7 (continued)

Patch #	Average L*	a*	b*
K1	35.77	-0.55	1.67
K2	38.50	-1.04	1.57
K3	41.86	-1.49	1.24
K4	34.46	0.23	2.62
K5	36.41	-0.36	2.35
K6	39.77	-0.89	2.18
K7	43.40	-1.64	1.95
K8	48.54	-2.18	1.25
K9	51.31	-2.59	0.95
K10	36.33	0.60	3.61
K11	39.13	0.58	3.36
K12	44.17	0.22	3.14
K13	50.13	0.08	2.78
L1	57.78	-1.54	2.56
L2	61.44	-1.55	2.39
L3	36.81	1.11	4.19
L4	40.75	0.82	4.05
L5	46.88	0.36	4.03
L6	53.72	-0.04	3.70
L7	63.09	-0.51	3.21
L8	67.17	-1.02	3.40
L9	36.99	-5.36	-0.46
L10	40.15	-5.53	0.59
L11	46.15	-4.64	0.77
L12	54.67	-4.00	1.11
L13	66.05	-1.76	1.75
M1	72.91	-0.85	3.28
M2	76.03	-0.70	3.29
M3	47.78	-18.57	-22.16
M4	46.95	34.94	0.48
M5	65.18	-2.13	46.04
M6	36.12	2.15	-18.63
M7	44.99	-29.04	12.92
M8	45.55	33.39	19.31
M9	47.16	4.21	-12.40
M10	54.40	-17.03	12.53
M11	54.44	18.04	18.32
M12	33.43	2.42	-13.45
M13	40.43	-22.15	9.93

Patch #	Average L*	a*	b*
N1	41.35	26.03	15.60
N2	41.99	3.60	-8.77
N3	48.67	-12.95	10.98
N4	48.28	14.88	15.00
N5	37.41	-9.38	-9.18
N6	37.32	19.26	1.71
N7	47.39	-1.20	25.38
N8	31.61	2.26	-9.00
N9	37.16	-16.03	8.63
N10	37.16	18.90	11.77
N11	36.46	2.88	-4.62
N12	40.46	-8.54	7.72
N13	41.05	10.39	11.10

Table H8. The average CIE LAB data of compensated 42μm FM screened IT8.7/3 target at High1 inking level (average of five samples)

	Average					Average		
Patch #	L *	a *	b *		Patch #	L *	a *	b *
A1	54.40	-23.36	-29.64		C1	56.48	-23.34	-28.00
A2	52.32	46.82	1.54		C2	58.39	-22.87	-25.99
A3	77.13	-1.42	59.64		C3	61.11	-21.70	-23.15
A4	38.33	4.26	-23.59		C4	63.19	-20.21	-20.32
A5	49.67	-36.71	14.46		C5	66.39	-17.47	-16.24
A6	50.21	45.19	24.83		C6	68.55	-15.37	-13.25
A7	35.80	-2.73	-1.31		C7	69.86	-13.76	-11.55
A8	43.35	5.81	-22.20		C8	70.94	-12.92	-10.31
A9	55.80	-33.11	15.73		C9	72.45	-11.08	-7.96
A10	54.24	39.66	22.13		C10	74.48	-8.33	-5.18
A11	56.22	5.48	-16.71		C11	76.44	-5.48	-2.19
A12	64.26	24.26	18.02		C12	78.15	-3.70	-0.21
A13	55.09	0.39	3.02		C13	80.18	-0.71	2.77
B1	65.21	-21.76	13.70		D1	52.65	46.88	1.50
B2	61.81	4.91	-12.42		D2	54.12	45.32	0.24
B3	70.01	-14.84	10.35		D3	56.10	42.70	-1.08
B4	68.19	17.68	14.02		D4	58.56	38.90	-2.12
B5	32.80	-5.67	-4.64		D5	62.38	32.68	-3.00
B6	33.65	14.58	2.54		D6	65.17	28.33	-2.89
B7	41.15	-0.49	17.97		D7	66.70	25.89	-2.76
B8	29.67	2.46	-5.86		D8	68.38	22.85	-2.37
B9	34.17	-11.92	6.15		D9	70.25	19.86	-1.72
B10	34.54	16.18	9.58		D10	71.69	16.98	-1.05
B11	29.44	-0.62	1.36		D11	75.02	11.46	0.70
B12	36.97	1.82	4.76		D12	77.04	8.00	1.82
B13	81.16	1.18	4.63		D13	79.65	3.81	3.34

Table H8 (continued)

	Average				Average		
Patch #	L *	a *	b *	Patch #	L *	a *	b *
E1	76.95	-1.06	58.32	H1	40.18	8.83	-13.24
E2	77.49	-1.48	54.76	H2	50.30	21.09	-3.19
E3	77.85	-1.88	50.02	H3	49.76	21.35	1.46
E4	78.28	-2.11	45.51	H4	45.52	27.06	7.84
E5	78.70	-1.91	38.61	H5	48.90	20.15	10.08
E6	79.22	-1.83	33.15	H6	48.62	20.89	16.15
E7	79.38	-1.55	30.39	H7	60.92	-1.45	23.22
E8	79.54	-1.65	27.84	H8	51.45	-19.63	16.64
E9	79.82	-1.18	24.33	H9	52.01	-18.77	9.57
E10	79.98	-0.69	20.01	H10	48.22	-24.48	3.06
E11	80.52	0.01	14.70	H11	53.95	-14.86	-9.44
E12	80.72	0.17	11.61	H12	41.35	-2.88	-17.01
E13	80.99	1.08	6.85	H13	44.85	3.72	-12.83
F1	38.42	2.03	4.78	I1	38.80	6.81	-2.06
F2	41.64	1.99	4.97	I2	47.96	15.31	-2.22
F3	45.12	1.98	4.97	I3	58.01	8.80	-0.11
F4	49.29	1.99	4.97	I4	39.00	6.36	2.42
F5	55.94	1.87	4.72	I5	57.63	7.39	6.09
F6	60.66	1.87	4.68	I6	41.91	0.13	5.02
F7	62.68	2.04	4.55	I7	53.83	0.26	13.62
F8	65.30	1.69	4.48	I8	62.24	-0.50	9.49
F9	68.29	1.67	4.56	I9	63.12	1.47	2.97
F10	70.61	1.67	4.34	I10	39.42	-7.77	1.53
F11	74.47	1.59	4.25	I11	49.19	-12.00	5.89
F12	76.65	1.53	4.27	I12	59.42	-6.73	5.70
F13	79.54	1.53	4.20	I13	40.74	-6.70	-3.68
G1	44.15	23.00	-12.95	J1	55.02	4.20	-3.77
G2	43.53	21.36	-2.84	J2	37.48	1.18	-5.75
G3	51.88	45.88	11.70	J3	59.42	-3.49	-1.29
G4	42.43	19.57	9.34	J4	50.37	-8.36	-5.13
G5	62.73	24.36	37.47	J5	30.77	0.12	0.80
G6	52.74	-0.69	21.07	J6	31.64	-0.11	0.53
G7	42.60	1.82	-0.69	J7	32.85	-0.13	-0.13
G8	64.23	-23.03	37.16	J8	32.11	0.08	0.79
G9	44.68	-19.44	7.75	J9	33.12	-0.19	0.47
G10	53.97	-32.19	-4.03	J10	34.68	-0.65	0.03
G11	46.77	-16.25	-10.16	J11	37.58	-1.52	-0.62
G12	47.67	-9.49	-27.87	J12	33.26	-0.26	1.65
G13	37.63	1.38	-13.17	J13	35.28	-0.56	1.59

Table H8 (continued)

	Average		
Patch #	L *	a *	b *
K1	37.90	-1.80	0.50
K2	42.41	-3.35	-0.41
K3	44.98	-4.05	-1.15
K4	35.47	0.78	2.87
K5	37.28	0.37	2.77
K6	41.46	0.24	2.70
K7	46.32	-0.27	2.00
K8	50.83	-1.10	1.89
K9	53.78	-1.77	1.29
K10	36.53	0.70	3.48
K11	39.11	0.51	3.37
K12	44.68	-0.29	3.03
K13	52.87	-1.19	2.44
L1	56.54	-3.02	1.38
L2	60.99	-3.85	0.82
L3	36.78	0.83	3.87
L4	40.28	0.70	3.98
L5	46.52	0.33	3.90
L6	55.79	-0.52	3.06
L7	61.62	-1.14	2.35
L8	67.55	-1.89	2.02
L9	37.27	-4.96	-1.07
L10	42.01	-6.43	-1.86
L11	50.58	-8.18	-1.82
L12	58.00	-4.25	1.63
L13	66.84	-5.29	0.50
M1	72.79	-2.89	1.27
M2	77.10	-1.13	2.83
M3	47.19	-18.08	-20.13
M4	46.55	32.72	0.11
M5	63.35	-1.96	43.16
M6	36.29	2.39	-17.91
M7	44.56	-27.76	12.30
M8	45.23	31.51	18.65
M9	50.36	3.06	-10.69
M10	57.10	-14.83	11.85
M11	56.17	15.20	14.55
M12	34.58	2.52	-14.92
M13	42.37	-24.49	10.75

	Average		
Patch #	L *	a *	b *
N1	42.32	27.33	16.07
N2	46.22	2.63	-8.26
N3	51.92	-12.30	9.65
N4	51.63	12.52	13.08
N5	37.48	-9.04	-7.75
N6	37.64	18.56	1.72
N7	47.09	-1.04	24.38
N8	32.25	2.40	-8.96
N9	38.22	-17.04	8.75
N10	37.89	18.95	12.04
N11	38.73	2.39	-2.72
N12	42.47	-6.78	7.23
N13	43.06	7.72	9.59

Table H9. The average CIE LAB data of 85-lpi AM screened IT8.7/3 target at High2 inking level (average of five samples)

	Average					Average	
Patch #	L *	a *	b *	Patch #	L *	a *	b *
A1	51.14	-23.01	-31.81	C1	53.02	-23.33	-30.26
A2	50.24	48.76	3.61	C2	54.68	-22.63	-28.38
A3	76.06	-0.32	63.91	C3	56.30	-21.50	-26.29
A4	35.08	3.65	-23.89	C4	58.04	-20.32	-24.03
A5	46.14	-36.72	14.98	C5	60.58	-18.55	-21.05
A6	48.10	46.57	26.54	C6	63.66	-16.48	-17.55
A7	33.27	-4.35	-0.10	C7	67.39	-13.27	-12.68
A8	37.86	7.30	-21.90	C8	69.03	-12.00	-10.71
A9	50.14	-32.62	19.42	C9	70.94	-9.93	-8.38
A10	50.30	43.26	27.09	C10	72.93	-7.94	-5.37
A11	47.88	8.95	-17.80	C11	74.94	-5.64	-2.61
A12	57.88	31.82	25.74	C12	75.98	-4.59	0.32
A13	46.03	3.54	6.06	C13	78.68	-1.99	1.41
B1	59.33	-23.72	19.12	D1	50.40	48.91	3.66
B2	60.28	6.38	-10.75	D2	51.18	48.15	3.11
B3	68.55	-13.09	13.87	D3	52.53	46.14	2.23
B4	66.77	17.38	19.30	D4	54.34	42.77	1.30
B5	29.94	-4.29	-4.12	D5	56.94	38.47	0.38
B6	31.04	12.59	3.04	D6	60.67	32.97	-0.28
B7	38.55	-0.59	16.99	D7	65.10	26.36	-0.20
B8	27.42	2.14	-4.14	D8	67.12	22.68	0.03
B9	31.68	-10.77	5.79	D9	69.18	19.59	0.20
B10	32.67	14.95	8.96	D10	71.24	15.93	1.21
B11	28.12	-0.85	1.60	D11	73.47	12.30	1.57
B12	33.53	1.62	4.14	D12	75.12	10.09	2.20
B13	80.37	1.54	4.88	D13	78.24	5.96	3.00

Table H9 (continued)

	Average				Average		
Patch #	L *	a *	b *	Patch #	L *	a *	b *
E1	76.05	-0.48	62.79	H1	37.23	7.75	-11.84
E2	75.95	-0.61	61.35	H2	47.04	25.62	-0.10
E3	76.14	-0.74	58.74	H3	46.12	24.71	7.81
E4	76.67	-1.06	54.72	H4	43.23	28.69	12.34
E5	76.93	-1.01	49.45	H5	45.31	24.47	14.76
E6	77.40	-0.85	43.74	H6	45.38	24.46	17.57
E7	77.96	-0.89	35.35	H7	58.46	-0.64	30.19
E8	78.40	-0.94	30.79	H8	46.72	-20.19	15.37
E9	78.86	-0.51	27.11	H9	46.51	-19.65	12.23
E10	79.01	-0.28	22.48	H10	43.36	-24.91	7.80
E11	79.58	0.27	17.17	H11	48.65	-14.98	-9.28
E12	79.17	0.44	15.00	H12	36.75	-1.33	-14.38
E13	80.54	1.04	9.45	H13	39.02	4.34	-11.77
F1	35.49	1.75	4.19	I1	36.42	4.86	0.81
F2	38.82	1.73	4.18	I2	42.25	14.18	0.99
F3	42.56	1.65	4.14	I3	53.20	15.16	2.39
F4	46.13	1.72	4.14	I4	35.95	4.57	2.20
F5	50.23	1.86	4.04	I5	52.81	13.19	12.44
F6	55.40	1.73	4.25	I6	37.21	1.09	4.08
F7	61.39	1.84	4.15	I7	46.69	1.25	13.98
F8	64.23	1.70	4.14	I8	59.72	0.75	17.76
F9	67.07	1.86	3.92	I9	60.62	2.55	5.59
F10	69.88	2.08	4.18	I10	35.60	-5.86	0.24
F11	72.88	2.25	4.08	I11	42.36	-8.34	6.03
F12	74.54	1.88	4.35	I12	53.54	-8.52	9.66
F13	77.77	2.08	4.11	I13	36.14	-5.59	-1.69
G1	41.05	21.29	-13.92	J1	48.15	6.03	-4.20
G2	39.84	18.01	-0.11	J2	34.55	-0.69	-1.63
G3	49.56	47.43	17.73	J3	55.04	-5.94	-2.01
G4	39.01	16.40	8.16	J4	43.18	-6.53	-1.93
G5	58.72	29.13	38.30	J5	28.66	-0.21	1.36
G6	45.82	1.21	16.76	J6	29.07	-0.47	1.23
G7	37.61	1.58	2.03	J7	29.97	-0.74	0.95
G8	58.66	-23.91	34.73	J8	29.53	-0.04	1.45
G9	38.80	-15.33	5.54	J9	29.60	0.03	1.56
G10	49.22	-34.29	2.43	J10	30.96	-0.42	1.22
G11	40.04	-13.05	-5.03	J11	32.26	-0.43	0.84
G12	41.66	-5.01	-26.96	J12	30.20	0.20	1.83
G13	34.73	-1.43	-8.05	J13	30.80	0.13	2.07

Table H9 (continued)

Patch #	Average L*	a*	b*
K1	32.85	-0.90	2.13
K2	35.69	-1.38	2.05
K3	38.51	-2.43	1.49
K4	31.78	0.11	2.74
K5	33.44	-0.33	2.45
K6	36.43	-0.90	2.57
K7	40.10	-1.71	2.28
K8	45.39	-2.51	2.18
K9	47.81	-2.60	1.82
K10	33.45	0.58	3.49
K11	36.03	0.56	3.33
K12	40.58	0.37	3.38
K13	46.82	-0.19	3.07
L1	55.25	-2.10	3.03
L2	58.78	-2.34	3.25
L3	33.58	0.93	3.74
L4	37.17	0.72	3.71
L5	43.27	0.15	3.86
L6	50.41	-0.21	3.62
L7	60.56	-0.84	3.28
L8	64.95	-1.26	3.50
L9	34.30	-4.94	0.24
L10	36.86	-5.09	1.19
L11	42.67	-5.03	1.84
L12	51.72	-4.25	2.13
L13	63.64	-2.33	2.44
M1	71.51	-1.68	3.80
M2	74.86	-1.56	3.14
M3	44.66	-17.71	-22.73
M4	44.55	35.19	1.54
M5	62.75	-1.62	46.68
M6	33.49	2.30	-18.13
M7	41.64	-28.18	12.13
M8	43.11	33.71	19.77
M9	43.86	4.32	-12.93
M10	51.33	-18.08	14.40
M11	51.48	19.06	19.63
M12	31.01	2.08	-12.47
M13	37.73	-20.92	9.59

Patch #	Average L*	a*	b*
N1	38.71	24.82	15.03
N2	38.48	3.36	-8.48
N3	44.79	-13.18	11.42
N4	44.70	14.48	15.58
N5	33.55	-7.62	-8.42
N6	34.39	17.39	2.42
N7	43.91	-0.97	23.38
N8	29.21	2.08	-7.30
N9	34.32	-14.55	7.53
N10	34.55	17.34	10.95
N11	33.27	2.72	-4.07
N12	37.24	-8.08	7.56
N13	37.90	9.84	10.65

Table H10. The average CIE LAB data of compensated 42μm FM screened IT8.7/3 target at High2 inking level (average of five samples)

	Average					Average		
Patch #	L *	a *	b *		Patch #	L *	a *	b *
A1	50.76	-22.90	-31.56		C1	53.29	-23.55	-30.20
A2	50.33	48.51	3.41		C2	55.94	-23.70	-27.89
A3	76.18	-0.76	63.97		C3	58.55	-23.01	-25.04
A4	35.78	3.48	-24.08		C4	60.89	-21.98	-22.37
A5	46.14	-36.77	14.72		C5	64.22	-19.63	-18.12
A6	48.30	46.48	26.75		C6	66.61	-17.44	-15.14
A7	33.41	-4.43	0.04		C7	68.04	-16.00	-13.39
A8	41.07	4.58	-23.08		C8	69.10	-15.04	-11.79
A9	53.01	-34.93	16.65		C9	70.93	-13.15	-9.25
A10	52.35	41.63	24.69		C10	72.93	-10.19	-6.34
A11	53.87	4.00	-17.94		C11	75.49	-6.92	-2.79
A12	62.68	26.19	20.80		C12	77.09	-4.89	-0.57
A13	52.44	-1.02	2.97		C13	79.65	-1.27	3.12
B1	63.29	-24.39	15.16		D1	50.35	48.87	3.56
B2	59.69	3.24	-13.80		D2	52.35	47.01	1.55
B3	68.18	-17.58	11.08		D3	54.64	43.81	-0.28
B4	67.04	18.28	15.95		D4	56.91	40.87	-1.50
B5	29.96	-4.26	-4.04		D5	60.98	34.45	-2.79
B6	31.19	12.59	3.07		D6	64.14	29.77	-2.82
B7	38.10	-0.52	16.25		D7	65.74	27.08	-2.72
B8	27.49	2.08	-4.25		D8	67.21	24.38	-2.43
B9	31.54	-10.57	5.57		D9	69.20	21.05	-1.85
B10	32.08	14.40	8.83		D10	70.93	17.81	-1.08
B11	27.91	-1.00	1.59		D11	74.37	12.06	0.65
B12	33.47	1.60	4.13		D12	76.33	8.70	1.82
B13	80.86	1.17	4.96		D13	79.38	3.95	3.39

Table H10 (continued)

Patch #	Average L*	Average a*	Average b*	Patch #	Average L*	Average a*	Average b*
E1	76.02	-0.41	62.49	H1	37.55	8.33	-12.52
E2	76.66	-1.07	58.68	H2	47.89	20.27	-3.10
E3	77.20	-1.86	54.15	H3	47.50	19.81	1.51
E4	77.67	-2.12	50.25	H4	42.98	26.20	8.06
E5	78.33	-2.22	42.41	H5	46.36	19.44	10.80
E6	78.83	-2.20	37.71	H6	46.06	19.64	17.52
E7	78.90	-1.94	34.14	H7	58.20	-3.09	24.09
E8	79.20	-2.06	31.62	H8	48.39	-21.40	17.44
E9	79.44	-1.71	27.74	H9	49.51	-20.51	10.15
E10	79.61	-1.02	22.68	H10	45.03	-25.78	3.11
E11	80.24	-0.41	16.82	H11	51.83	-16.49	-9.35
E12	80.38	0.00	12.97	H12	38.68	-4.05	-17.23
E13	80.84	0.89	7.71	H13	42.62	2.16	-12.82
F1	35.24	1.74	4.37	I1	36.51	5.63	-2.25
F2	37.97	1.84	4.63	I2	45.24	14.10	-2.06
F3	41.52	1.91	4.81	I3	55.95	7.19	-0.04
F4	46.08	1.85	4.97	I4	36.45	5.00	3.20
F5	53.20	1.77	4.86	I5	55.33	5.95	6.79
F6	58.59	1.73	4.92	I6	39.72	-2.23	6.32
F7	60.95	1.78	4.63	I7	51.39	-1.89	14.70
F8	63.36	1.63	4.60	I8	60.22	-2.02	10.64
F9	66.38	1.66	4.60	I9	61.00	-0.22	3.53
F10	69.39	1.69	4.30	I10	37.06	-10.03	2.51
F11	73.40	1.58	4.34	I11	46.78	-13.63	6.64
F12	75.83	1.58	4.24	I12	57.32	-8.55	6.45
F13	78.85	1.72	4.26	I13	38.60	-8.70	-3.69
G1	41.45	21.91	-13.19	J1	52.42	2.52	-3.71
G2	40.81	20.25	-3.08	J2	34.78	0.29	-5.37
G3	49.83	47.71	13.42	J3	57.15	-5.18	-1.20
G4	39.66	18.40	9.51	J4	47.63	-9.83	-5.11
G5	61.05	26.20	40.62	J5	28.82	-0.54	1.02
G6	49.94	-2.07	22.02	J6	29.62	-0.71	0.96
G7	40.32	-0.18	-0.15	J7	30.63	-1.03	0.35
G8	61.51	-25.22	38.16	J8	29.86	-0.53	1.02
G9	41.70	-21.50	7.94	J9	31.05	-0.84	0.82
G10	50.82	-33.32	-4.89	J10	32.70	-1.55	0.19
G11	43.78	-17.24	-10.44	J11	35.27	-2.28	-0.46
G12	45.09	-9.81	-29.66	J12	30.74	-0.42	1.61
G13	35.48	0.40	-13.29	J13	32.76	-0.74	1.54

Table H10 (continued)

	Average		
Patch #	L *	a *	b *
K1	35.39	-2.13	0.68
K2	39.56	-3.99	-0.38
K3	42.17	-5.11	-1.23
K4	32.65	0.34	2.54
K5	34.48	-0.06	2.50
K6	38.56	-0.69	2.38
K7	43.56	-1.43	1.75
K8	47.87	-2.37	1.44
K9	51.11	-2.91	1.17
K10	33.41	0.44	2.96
K11	36.01	0.16	3.03
K12	41.82	-0.72	2.85
K13	49.85	-2.06	2.13
L1	53.73	-4.24	1.15
L2	58.00	-5.38	0.15
L3	33.78	0.65	3.40
L4	36.89	0.54	3.65
L5	43.20	0.02	3.64
L6	53.27	-1.05	2.92
L7	59.30	-1.76	2.21
L8	65.63	-2.87	1.84
L9	35.19	-6.50	-1.01
L10	39.75	-7.80	-1.59
L11	47.79	-9.27	-1.85
L12	55.32	-5.40	1.83
L13	64.62	-6.96	-0.08
M1	70.98	-4.23	1.01
M2	76.10	-1.83	2.70
M3	43.93	-17.05	-20.75
M4	44.20	33.04	1.23
M5	61.47	-1.61	44.27
M6	34.05	2.18	-17.77
M7	41.56	-27.63	11.83
M8	43.10	32.15	19.31
M9	47.64	2.31	-11.33
M10	54.27	-16.56	11.96
M11	53.97	15.85	15.26
M12	32.31	2.38	-14.35
M13	40.06	-24.38	11.07

	Average		
Patch #	L *	a *	b *
N1	40.01	27.34	16.10
N2	43.17	1.98	-8.37
N3	48.50	-13.14	9.34
N4	48.87	12.42	13.43
N5	34.11	-7.68	-7.62
N6	34.87	17.09	2.44
N7	44.32	-0.96	23.36
N8	29.65	2.42	-7.33
N9	35.24	-16.02	7.98
N10	35.44	18.33	11.61
N11	35.82	2.03	-2.61
N12	39.12	-6.77	6.61
N13	39.94	7.35	9.18